The Resource Journal for IBM Micro Programmers

PROGRAMMER'S Journal

JULY/AUGUST 1988
Volume 6.4
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Opening Windows

Windowing Systems Overview
by Frank D. Greco

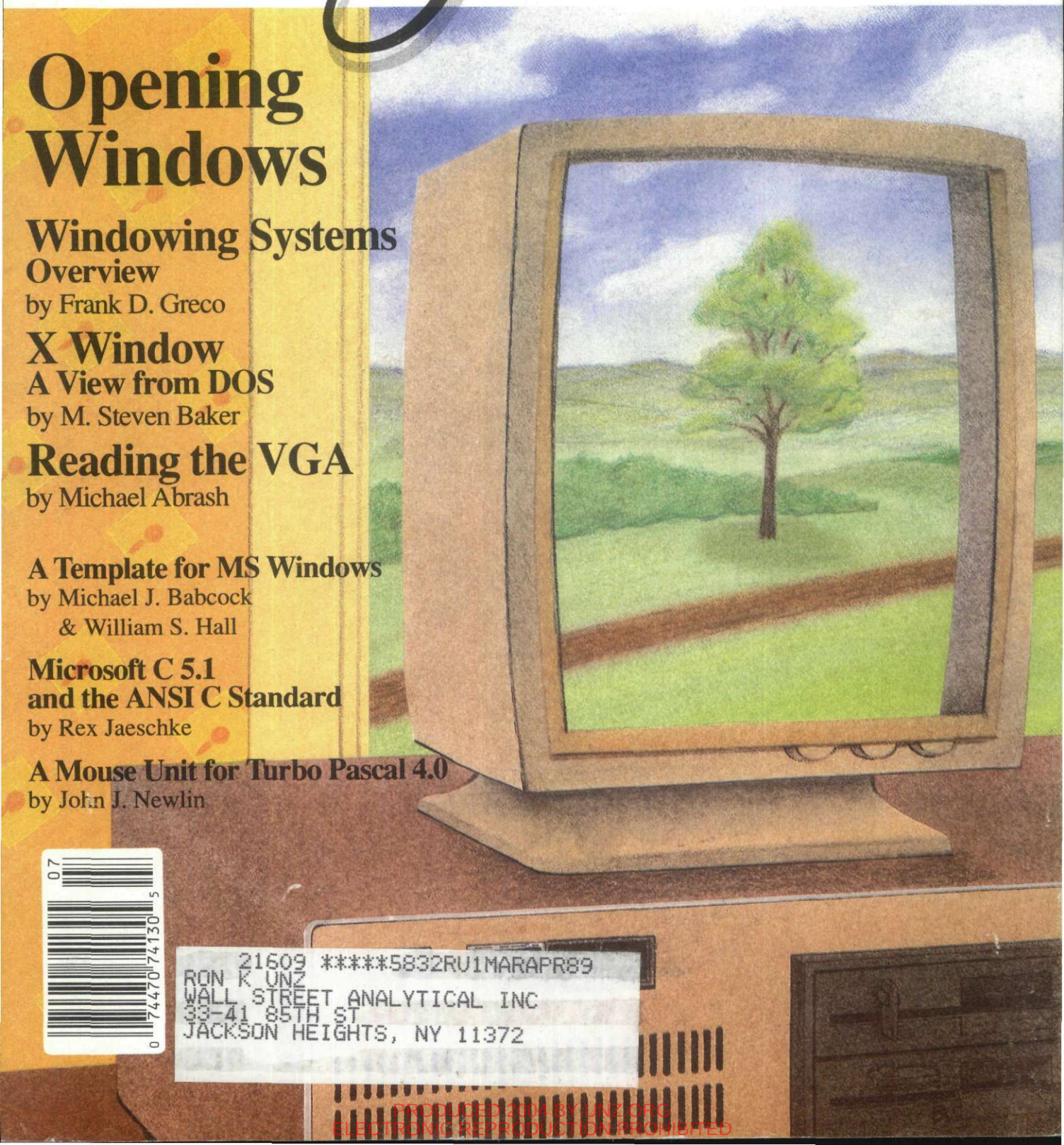
X Window A View from DOS
by M. Steven Baker

Reading the VGA
by Michael Abrash

A Template for MS Windows
by Michael J. Babcock & William S. Hall

Microsoft C 5.1 and the ANSI C Standard
by Rex Jaeschke

A Mouse Unit for Turbo Pascal 4.0
by John J. Newlin



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Computer Language	February 1986, '87	
Dr. Dobb's Journal	August 1986	
PC Magazine	Jan. 27, 1987	(80386 version)
Dr. Dobb's Journal	July 1987	(80386 version)
BYTE Magazine	November 1987	(80386 version)

- **Professional Pascal ™:**

PC Magazine	Dec. 29, 1985	
Computer Language	May 1986	
PC Tech Journal	July 1986	
Journal of Pascal, Ada, & Modula-2	Nov.-Dec. 1986	
BYTE Magazine	Dec. '86, June '87	(80386 version)

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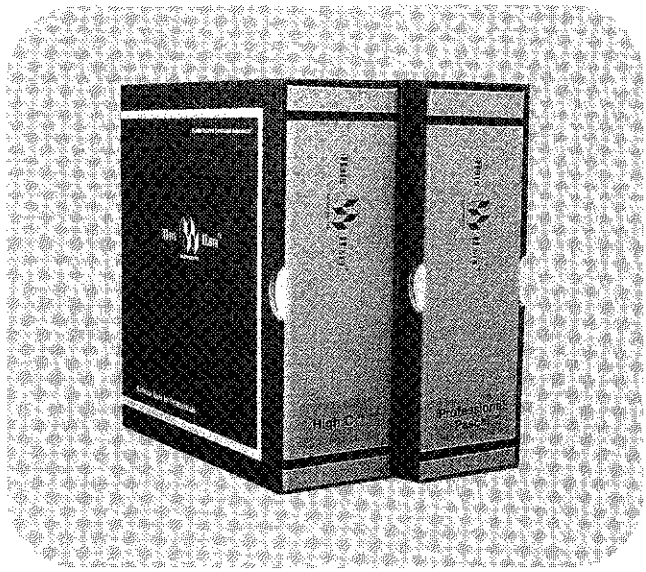

Power Tools for Power Users

Ashton-Tate: dBase III Plus, MultiMate; Autodesk: AUTOCAD, AUTOSKETCH (8087, '387, Weitek); Boeing Computer Services (Sun); CASE Technology (Sun); CAD/CAM giant Daisy ('86, '386, VAX); Deloitte Haskins & Sells; Digital Research: FlexOS; GE; IBM: 4.3/RT, 4680 OS; Lifetree Software (Pascal): Volkswriter Deluxe, GEM-Write; Lugaru: Epsilon; NYU: Ada-Ed cmplr; Semantec: Q&A; Sky Computers; ... (Product names are trademarks of the companies indicated.)

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386 32-bit DOS	— no competitors, since November, 1986.
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The Resource Journal for IBM Micro Programmers

PROGRAMMER'S Journal

Volume 6.4
July/August 1988

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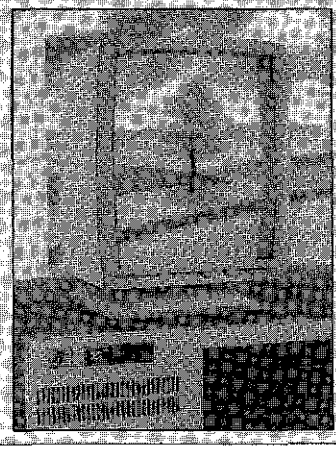

Will windowing ever open up on an idyll? Artist Ralph Bentley reminds us Oregonians there's good reason to endure the winter rains. Oregonians get their payoff. May there be an analogy in there somewhere, a multitasking graphical dream come true.

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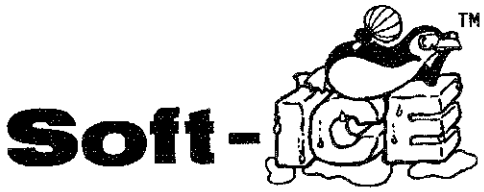

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NOTES from the Editors

"Inventing Edwin Land" was the attention grabbing blurb on a recent cover of the *New York Review*, the point being, of course, that the reclusive Land has been a mystery of such a high order—right up there with J.D. Salinger—that his biographers have had to invent him. They've succeeded to a degree. Two books on Land have come out recently.

Programmers are perforce inventing windows. Among proliferating windowing systems and system calls, without a standard, and within windowing systems whose parts themselves don't conform to one another, programmers are succeeding to a degree with a routine here, a template there—recipes. If the post-modern genius is for living with uncertainty, the optimistic line of argument should maintain that our present suspension among immature and inconsistent windowing systems is a splendid opportunity for innovation. Promethean words like "independent," "heuristic," "powerful," "ambitious," should roll trippingly off the tongue. And proponents of "open endedness" should regret that thirty-six companies have gotten together to ensure that the "Open Look" will turn out to be anything but.

If Frank Greco's right, the "Open-endians" don't have much to worry about. Frank takes us on a quick tour of the contending systems and concludes that the thirty-six may, perhaps regrettably, accomplish a uniform Mac-like user interface, but that we're in little imminent danger of standardization otherwise. Wading into the divergent specifics, our Technical Editor Steve Baker has managed to get the monolithic X Windows source code into the PC and has several good ideas about where to go from there. X Windows grew out of the premise that there's no particular virtue in a mandated "look and feel" standard—different types of users and different kinds of applications call for appropriate, not standard, interfaces. John Navas takes a pan-system approach to some video BIOS extensions that allow for well-behaved and fast software performance, be it under TopView, DESQview, or Windows. Michael Babcock and William Hall provide a template that lets us get started on Microsoft's Windows now, and undocumented information of strategic value shows up right away. Next issue, Hall and Babcock will demonstrate with the same project that Windows and the Presentation Manager are not sisters under the skin.

Hobgoblin—with a foolish consistency, we misnamed Richard Wilton's *Programmer's Guide to PC and PS/2 Video Systems* (Microsoft Press) throughout Volume 6.3 (May/June 1988). Michael Abrash recommends the book in this issue—and gets its name right.

Don't let the "second edition" on the cover of Contributing Editor Tom Swan's *Mastering Turbo Pascal 4.0* mislead you. Like the compiler, the 774-page tutorial/reference book is practically brand new. Tom wrote over half the material just for the 4.0 edition and revised the rest. A code disk is available. (Hayden Books, Howard W. Sams & Co., 4300 West 62nd Street, Indianapolis, IN 46268, 317/298-5400)—*Erin*

One of my ongoing complaints about PC system software is with "undocumented features." DOS contains a number of undocumented features used by programs supplied with the system. The undocumented TSR functions are the classic, but not the only, example. I recently spent several hours poring through the Microsoft Windows SDK documentation trying to find any mention that Windows supports certain TopView system calls. These calls allow programs to be "windows aware" without a major rewrite of an application. Why wasn't this documented? And while porting a version of X Windows to the PC, I disassembled the new Microsoft Mouse driver to see the details of the hardware interface (not documented, of course). Lo and behold, I found undocumented Microsoft Mouse function calls. Would you be surprised to hear of undocumented features in OS/2 or the Presentation Manager? From my perspective, there should be no such thing as an undocumented feature.

In a similar vein, several knowledgeable folks have told me that the Intel 80386 chip is not as solid as they would like (but there are already a million of them out there now, and lots more to come). One bug, which Intel refers to as Erratum 21, can cause the machine to hang under the right circumstances when executing 80387 instructions when paging is enabled. This is a problem with the 80386 (not with the 80387), and some newer machines have been designed with a hardware workaround. Although this problem has been documented since early last fall, Intel is not supposed to correct the chip until sometime this summer. Compaq's 386 *Technical Reference* manuals do a good job of documenting their high end machines, but also provide an excellent list of 80386 bugs and possible workarounds. I highly recommend them.

I'd like to close on the issue of "compelling applications"—by this I mean new programs so attractive and powerful that they generate purchases no matter what environment they are available on. The recent announcement that Interleaf (Cambridge, MA) has ported their high end publishing software to 80386 PCs would be my current example of a compelling application for 386 DOS extenders. This high end software package was once available only on expensive minicomputers and workstations with virtual memory. Now it will run under DOS on machines with 5 megabytes of memory. In a strange quirk of fate, IBM has negotiated distribution rights for a program that isn't based on OS/2 or AIX. Interleaf developers used Phar Lap's 386|DOS Extender software and MetaWare's 386 C compiler and praised the support from both companies. Although program developers may be able to use OS/2 now, it clearly lacks compelling applications for users. Whether and when compelling applications for OS/2 arrive will determine its success.—*Steve* ♦

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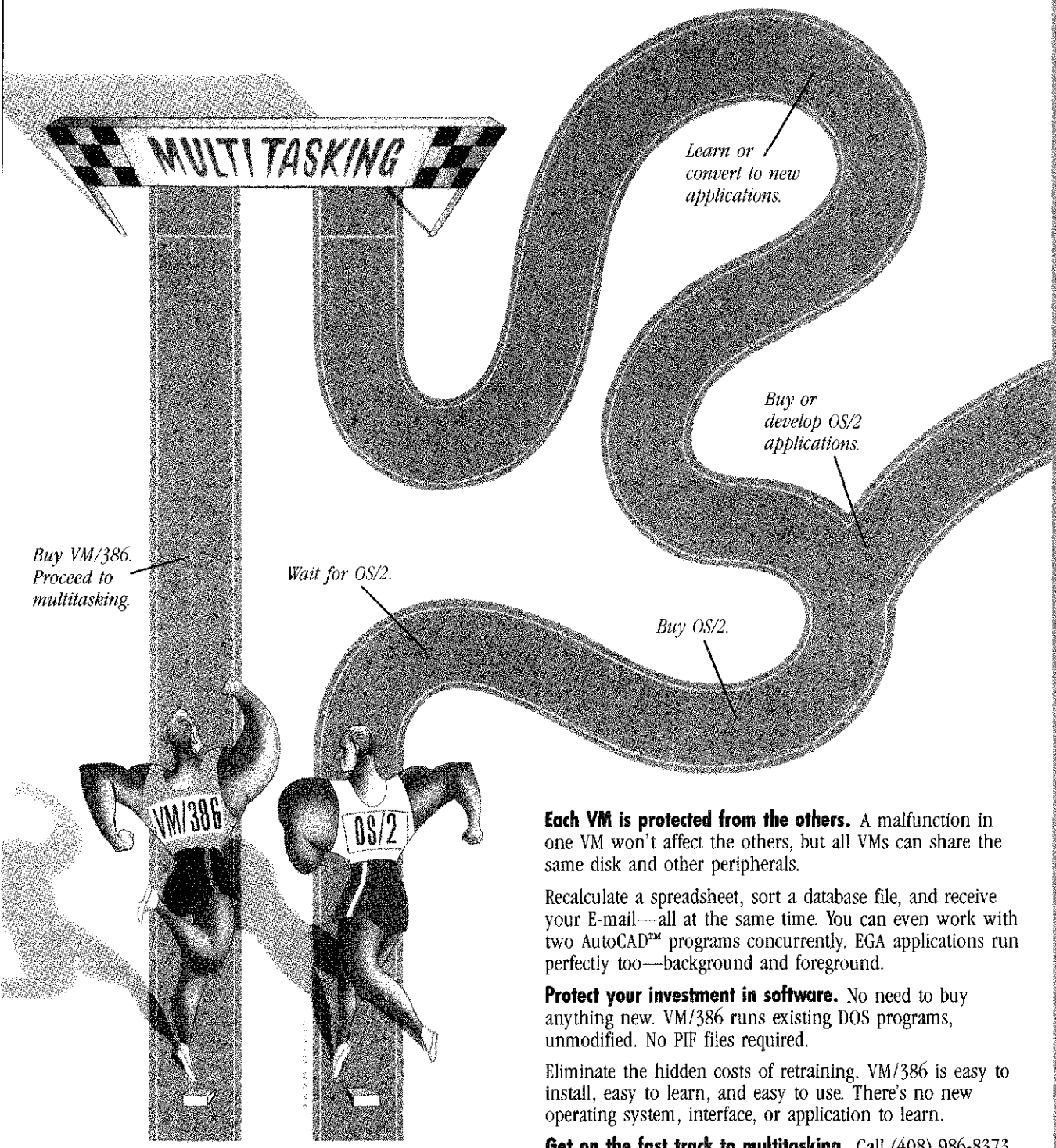

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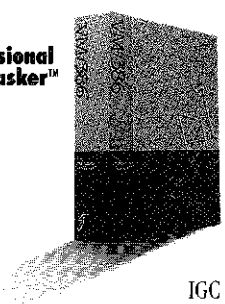

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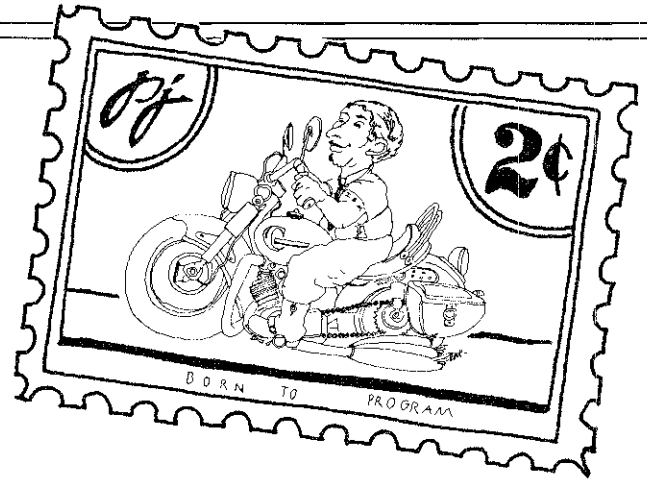

Resident Difficulties

I need some information concerning the ASM program at the end of Graham Pearson's article, "Coding Guidelines for Resident Programs," in the March/April 1987, issue (Volume 5.2).

I have not been able to get the program to operate correctly. I think the line

```
mov     ax,2509H
```

after

```
restore_int24:
```

should read

```
mov     ax,2524H
```

Also, are there other errors? Is there a way to download a working copy of the ASM file?

Richard Sanders
Longmont, CO

Graham Pearson Replies

Richard is correct; there is a typo in the assembler code accompanying the article "Coding Guidelines for Resident Programs," *PJ* 5.2, March/April 1987. The correct segment of assembler code is:

```
restore_int24:
        lds     dx,int_24_vect
                ;Restore INT 24H
        mov     ax,2524H
        int     21H
```

There are no other errors in the listing. The corrected assembler source code has been supplied to *PJ* and can be obtained on either their BBS's or their Issue Disk or from me.

Graham Pearson
Kudos Software
9111 Cadawac
Houston, TX 77074
(713) 774-6108

The "Roll Call" Interrupt

In reference to Ben Myers' letter in *PJ* 6.3 and Michael Young's response, I'd like to help clarify the "roll call" interrupt. I believe Mr. Myers is referring to interrupt 2Fh (*not* 28h), called the "multiplex interrupt" in IBM literature. (Interrupt 28h performs a very different function and is used extensively in TSR programs to tell when it's "sort of" safe to enter DOS even when DOS is already busy.)

The multiplex interrupt has been used since DOS Version 2 to handle interprocess communications in programs like DOS PRINT. In PRINT, print function requests (queue file, dequeue file, show queue list, etc.) can be passed from a transient instance of PRINT to the memory-resident PRINT via the multiplex interrupt, just as any software interrupt could be used. The advantage of the multiplex interrupt is that a protocol has been defined that allows multiple dissimilar programs to share the same interrupt vector.

Although the multiplex interrupt has been around for quite a while, the first place I saw it defined was in the IBM DOS Version 3.1 *Technical Reference* manual. In brief, the multiplex interrupt is used as follows:

- First, each multiplex handler (that is, each program processing multiplex interrupt requests) is assigned a "multiplex number" (which I choose to call a Process ID or PID). Although 256 PIDs (00h–FFh) are available, user programs are allowed to use PIDs C0h through FFh only.
- Each multiplex handler then installs itself into the multiplex interrupt chain (by first getting and saving the current interrupt 2Fh vector address and then by pointing the 2Fh vector to the new handler routine). In all probability, the multiplex handler will become a terminate-and-stay-resident program, but it certainly doesn't have to.
- A client process (that is, a program making a multiplex interrupt request) places the appropriate PID in AH, a function code (more or less multiplex handler dependent, but see below) in AL, and other information in other registers as necessary. Then interrupt 2Fh is executed.
- Upon receiving the interrupt, the multiplex handler examines the PID in AH. If AH does not contain the correct PID, the handler is expected to chain to the next multiplex handler in the chain. The function code in AL is also examined. If the function code is in the range F8h to FFh, regardless of the PID in AH, an immediate IRET is executed (God only knows why, but that's what the specification says); otherwise, the multiplex handler processes the multiplex interrupt, returning to the client with an IRET. Values may be returned to the client via registers or by any other mechanism understood by both parties.
- Function code 0 (Get Installed State) must be supported by all multiplex handlers. Upon return from a multiplex interrupt with function 0, AL is expected to contain one of three values: 0 if the requested handler is not installed but it's okay to install it, 1 if the requested handler is not installed and it's not okay to install it, or FFh if the handler is already installed.

A couple warnings:

- Some of the PIDs are already in use by third-party software. There's no telling who has what, so you may inadvertently walk on top of someone else's PID. IBM suggests that the PID be a data variable and not an equate so that it can be patched should a conflict occur.
- Some versions of DOS, notably many Version 2s, do not initialize the interrupt 2Fh vector. This affects both the multiplex handler and client processes as follows: If the multiplex handler is required to chain to the next handler, the next handler address must first be checked and, if it is zero, an IRET executed instead; if the multiplex client wishes to execute an interrupt 2Fh, it should ensure that the multiplex interrupt vector has been initialized.

The accompanying code fragments below highlight most of these points.

I use the multiplex interrupt frequently in my TSR programs. It is reliable, efficient, and, for the most part, safe. To be honest—it takes a little longer to set up and is bound to cause problems the first couple of times through, but it works, and it works well once you get the hang of it.

For more information, the IBM DOS Version 3.x *Technical Reference* manual is, as usual, an invaluable resource.

Keith Spitz
Microcomputer Systems Manager
Computing Services
CH2M Hill, Inc.
Bellevue, WA

Code follows.

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Code from Letters—"Interrupt" by Keith Spitz

```
;*****************************************************************************
;
; This program fragment shows how the multiplex interrupt can be used to
; provide reliable interprocess communications in an MS-DOS environment.
; A single segment is assumed (i.e. a .COM file) throughout this fragment,
; so adjustments will be necessary in a multiple segment situation.
;
; Keith Spitz / CH2M HILL Inc. / May 4, 1988
;
;*****************************************************************************

;
; Define the segmentation.
;
CODE            SEGMENT                         ; A single segment.
                ASSUME  CS:CODE , DS:CODE       ; Everything goes in it.

;
; Program Data.
;
MyPIDHeader     DB      'MYPID'                 ; Helps me find MYPID if
                                                ; patching is necessary.
MyPID           DB      0C0h                    ; Assigned multiplex number.
MPXAddr         DD      ?                       ; Address of original multi-
                                                ; plex interrupt vector.

;
; See if this process is already installed.  If so, this program becomes a
; client.  If not, this program installs itself and becomes the multiplex
; handler.
;
CheckInstalled: mov     ah,MyPID                ; PID in AH.
                mov     al,0                    ; Get Installed State function.
                call    MPXInt                  ; Do the interrupt.
                cmp     al,0                    ; Not there but OK to install?
                je      DoInstall               ; Yes - become handler.
                cmp     al,1                    ; Not there and NOT OK to inst?
                je      CantInstall             ; Yes - bomb out.
                cmp     al,0FFh                 ; Already installed?
                je      AlreadyInstalled        ; Yes - become client.
                jmp     Hmmmm                   ; Hmmm.  Bomb out, I guess.

;
; At this point, the program needs to become the handler process.  It installs
; itself into the multiplex interrupt chain and then (presumably) becomes
; memory resident.
;
DoInstall:      mov     ah,35h                  ; Get interrupt vector func.
                mov     al,2Fh                  ; For the multiplex interrupt.
                int     21h                     ; Get vector.
                mov     WORD PTR MPXAddr[0],bx  ; Save offset of vector.
                mov     WORD PTR MPXAddr[2],es  ; Save segment of vector.
                mov     ah,25h                  ; Set interrupt vector func.
                mov     al,2Fh                  ; For the multiplex interrupt.
                mov     dx,OFFSET MPXHandler    ; Point at handler routine.
                int     21h                     ; Set new vector.
                ...                             ; Off to do whatever...

;
; If the program gets here, the program has decided it is a client process.
; It will perform a couple of multiplex interupt requests and then quit
; (or whatever).
;
AlreadyInstalled:mov    ah,MyPID                ; PID in AH.
                mov     al,<some function>      ; Some process func in AL.
                call    MPXInt                  ; Do the function.
                ...                             ; ... Do other things ...
                mov     ah,MyPID                ; PID in AH again.
                mov     al,<another function>   ; Another function in AL.
                call    MPXInt                  ; Do the second function.
                ...                             ; ... Do more other things ...

;
; This is the multiplex interrupt handler.  It will handle only those
; requests appropriate for the current process and pass on requests not
; for this process.  Note that DS is probably not pointing to the right
; place at the onset.
;
MPXHandler      PROC    FAR                     ; This MUST be a FAR routine.
                cmp     ah,CS: MyPID            ; Is this for us?
                jne     MPXHandNext             ; No - chain to next handler.
                cmp     al,0F8h                 ; Reserved function?
                jae     MPXHandRet              ; Yes - return immediately.
                cmp     al,0                    ; Get install state function?
                je      MPXHandFunc0            ; Yes - handle it.
                ...                             ; Check for other funcs here.
                mov     al,<Invalid function>   ;Invalid function.
                jmp     MPXHandRet              ; All done.
; Handle the 'Get Install State' function.
MPXHandFunc0:   mov     al,0FFh                 ; Yes, we are installed.
                jmp     MPXHandRet              ; All done.
; Chain to the next handler, if there is one.
MPXHandNext:    mov     ax,CS: WORD PTR MPXAddr[0] ; Offset of next in chain.
                or      ax,CS: WORD PTR MPXAddr[2] ; OR in segment.
                je      MPXHandRet              ; If 0, no one to chain to.
                jmp     CS: MPXAddr             ; Else chain to next handler.
; Return from the interrupt.
MPXHandRet:     iret                            ; All done.
MPXHandler      ENDP                            ; End of handler procedure.

;
; This routine is used to perform multiplex interrupts.  Direct INT 2Fh's
; should not be called since it is possible that the 2Fh interrupt vector
; has not been initialized in some versions of DOS.
;
MPXInt          PROC    NEAR                    ; Start of procedure.
                push    ax                      ; Save AX, BX, and ES ...
                push    bx                      ; ... while they are used ...
```


Code continues . . .

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Spitz Code, Continued

```
                push    es                      ; ... to see if INT 2Fh is OK.
                mov     ah,35h                  ; Get interrupt vector func.
                mov     al,2Fh                  ; For the multiplex interrupt.
                int     21h                     ; Get vector.
                mov     ax,es                   ; Get the vector segment.
                or      ax,bx                   ; Or in the offset.
                pop     es                      ; Restore registers now...
                pop     bx                      ; ... (leaving flags alone ...
                pop     ax                      ; ... for later testing).
                jz      MPXIntRet               ; If addr was 0, no vector!
                int     2Fh                     ; Otherwise OK to do INT 2Fh.
MPXIntRet:      ret                             ; All done.
MPXInt          ENDP                            ; End of procedure.

CODE            ENDS
```

Two Questions

In *PJ* 6.3 (May/June 1988), you answer Konrad Wiley's letter by referring to your BBS. This sounds interesting. What is it? How can I get on it?

The second question's more technical: In house we have several Wang minicomputers and a variety of IBM PC clones. We have been printing Wang documents on PC printers by sending them asynchronously, in background, to a PC. We used a hardware interrupt to effect the operation.

We would like to do the same sort of operation, but printing off the Wang minicomputer using a parallel port and inputting the data on the PC on its parallel port. I've heard that packages exist that do this. Is there any way of using a parallel printer port as an input port? If there is, is there anything written up on how to do it using Assembly Language?

Mark Brand
Vice President
Securities Information Services, Ltd.
Passaic, NJ

You can get any of the code that appears in an issue of the magazine on any of the three PJ *bulletin board services (see the PJ Billboad page), or you can order an Issue Disk (see the order card).*

The IBM PS/2s can read and write data through their parallel ports. IBM still sells a cable and software to let you download from older PCs to the PS/2 using the parallel ports, but this kit won't allow sending to the PC. We also put your second question to the expertise of our neighbor to the east Dave Thompson, Editor of Micro Cornucopia *in Bend. Dave wasn't encouraging. Most parallel ports are hardwired for receiving data, and converting a parallel port to input data may involve major surgery depending on your hardware. Dave added that people like serial ports because they're bi-directional.—Ed.*

Reply to Dennis Reinhardt

I'd like to reply to Dennis Reinhardt's letter on OS/2 and PS/2 in your 6.3 issue. We do all of our development on an IBM PS/2 Model 80 and an IBM AT. Our product goes out on 5.25-inch floppies just as yours does. We have had only two requests for the 3.5-inch medium just as you have. This does *not* mean that people are staying away from PS/2 systems. Two kinds of products available for PS/2 machines will remedy the 3.5-inch disk problem: (1) external 5.25-inch floppy disk drives—now available for high density diskettes as well as for standard double-sided diskettes—the high density version is available for under $200; (2) "bridge" programs that allow the transfer of files via parallel or serial cable from one PC to the next (for example, from an XT or AT to a PS/2). These are available for about $60.

I, as well as multitudes of other PS/2 owners have one or the other of these two options (I have both). It doesn't make sense to buy a powerful computer system such as the PS/2 and not be able to read 5.25-inch diskettes. Most people who buy PS/2s are also buying external disk drives. One manufacturer of these drives known personally to me has trouble keeping up with the demand for them. That people aren't asking for our software on the 3.5-inch medium doesn't mean that they don't have PS/2s. A 5.25-inch diskette is preferable because it can be read by all machines as well as by a PS/2 with an external floppy drive.

As for OS/2, we're developing software for that right now. We can't afford to sit back and see if the market will want OS/2. If you'll recall, back in the days when CP/M was the dominant operating system for microcomputers everyone thought it was there to stay. When IBM first introduced the PC in 1981, nobody believed DOS would prevail over CP/M. After all, thousands of programs were available under CP/M, and almost nothing was available for DOS. The same thing is happening today—OS/2 is available now, applications for it are starting to show up, and we have the benefit of running DOS programs under it when we need to. A *true* multitasking operating system with virtual storage, micro-channel, and the ability to handle 16 Mb of RAM on the system is apples compared to the single-user DOS system oranges. Everyone has problems with "resident" programs running under DOS—Program W won't run right with Program X, which clobbers Program Y, which doesn't leave enough available memory for Program Z's operation! With OS/2, these problems won't exist—everything will run together without our having to worry about whether Program X modified the same interrupt vector that Program Y did.

So yes, we too could stand still with our AT and DOS and a "wait-and-see" attitude about whether the market will turn to PS/2s and OS/2. But what if we waited and saw that the market *did* take this turn—by that time it would be too late because the market would be overflowing with OS/2 applications and our program would be just another competitor. If IBM and Microsoft are willing to take the gamble, I am, too. Does anyone else agree?

Chuck Gilmore
Gilmore Systems
Beverly Hills, CA

Efficient Jump Tables

I'd like to clarify one point about the assembly language program that Tom Swan provided in his article "A CASE of the Jumps" in Volume 6.3. Mr. Swan stated that " . . . there is one main disadvantage to using jump tables. If your case selector values are widely separated, you must insert dummy offsets into the table." This is true only for the code that Mr. Swan provides; there are more efficient ways to implement jump tables. I recommend the following changes to Mr. Swan's Listing 2:

1. Insert a table to valid selector values in the data segment.

2. Add the offset of the endcase procedure to the offset table.

3. Initialize ES at the program start.

4. Use the 8088 "SCASB" opcode to locate the correct procedure.

This is how the accompanying routine works: DX is initialized with the offset of the error message (as in the original listing), and DI is initialized with the offset of the character table. The processor scans through the table and stops when a match is found for the character contained in AL (DI will point to the matching character). If no match is found, DI points to the character past the end of the table. The offset of the character table is subtracted from DI, yielding a value equal to the offset of the matching character within the table. This value is multiplied times 2 to produce the corresponding word sized offset within the jump table. If no matching character was found, the result in DI will be the last offset in the jump table, which, in this case, is the endcase procedure.

Continued . . .

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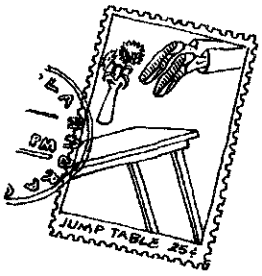
This method will always execute the endcase procedure when an invalid character is placed in AL, regardless of how widespread the selector values may be. This is accomplished without adding unnecessary offsets to the jump table.

Adrian B. Crum
La Habra, CA 90631



Tom Swan Replies
While Mr. Crum has an interesting idea, I disagree that his solution is "more efficient." In good jump table programming, the data are used at random in calculating indexes into the table of addresses, which point to the routines that are to be executed for particular data elements. A classic jump table or Pascal CASE statement (not Turbo's, though) operates at the identical speed for all possible input values.

```
------------------------------------------------------------
        .DATA

;-----  Command  character list

chars   DB      "0123"
lchars  EQU     $-chars             ; length of command character list

;-----  Jump (case) table of addresses

table   DW      case0,case1,case2,case3,endcase

;-----  Various strings

etc...

------------------------------------------------------------------
        .CODE
start:
        mov     ax,@data            ; initialize DS & ES
        mov     ds,ax
        mov     es,ax

etc...

------------------------------------------------------------------

;-----  Prepare DI equal to the case statement number times2,
       indexing the 2-byte addresses in the jump table.

        mov     dx,OFFSET errmsg    ; Prepare for possible error
        mov     di,OFFSET chars     ; Point to command character table
        mov     cx,lchars+1         ; Load length of character table
        cld                         ; Scan forward
        repne   scasb               ; Find the command character
        sub     di,OFFSET chars+1   ; Point to procedure
        shl     di,1                ; Convert to word address
        jmp     table[di]           ; Jump to case 0,1,2,3, or endcase

etc...

------------------------------------------------------------------
```

Continued . . .

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The problem with Mr Crum's code is the REPNE SCASB instruction, which scans a string of test characters. Suppose this string contains the letters ACFHKMPRTWZ. Obviously, scanning for the letter A takes the least time while scanning for Z requires examining 10 previous characters. True, such a scan will not take a lot of time, but it will take some time. Inputting a zillion Zs will cause the program to run more slowly than inputting an abundance of As.

This reintroduces the very problem I was trying to solve in the article. Because Turbo Pascal compiles CASE statements to a series of compare and jump instructions, the higher labeled statements take less time to execute than the lower ones. Using a jump table dramatically improves execution time by giving all input values a fair shake. Inserting dummy entries for unused labels guarantees that the CASE statement will operate in the same amount of time for all input values, an important quality in programs that require detailed analysis of execution times, or in code that must be synchronized with other events.

These dummy entries waste memory, as I pointed out. To reclaim this space, you can use a solution like Mr. Crum's, sacrificing speed and evenness to save a few bytes, or you can use my solution, which gives the best running times at the expense of a little memory. As it is so often, your choice is speed or memory savings. You can't have it both ways.

Tom Swan
Lititz, PA

Controlling the Beep

I'm a relatively new reader of *PJ* and have just sent in for my subscription. So far I'm pretty impressed by the publication.

In our work we use the Compaq 386/20 as a controller for a specialized piece of hardware. We use the default beep on the computer for audible feedback. Unfortunately, the default beep has changed many times and is actually long enough in duration now to slow our other processing. We would like to continue to use the default beep (triggered by a Ctrl-G sequence written to the standard output device), but would prefer to be able to change the duration and tone permanently. We have some older installed systems that use IBM AT computers as controllers, and basically, every model has a different beep. We'd like a solution that can be used on any compatible machine if that's possible. If it's in the BIOS, that may be a problem, but we think it is possible that we could modify the ANSI.SYS driver (which we currently use as a standard practice). The beep may not seem like a big deal, but believe me, it would be very helpful to be able to control it. We know how to control the beep as a general interrupt call, but the default tone still escapes us.

Peter C. Gustafson
W. Melbourne, FL

We've said for a long time now that what the PC needs is a good "thud." Of the approaches you might take, revising the ANSI.SYS driver seems like the weakest—it probably makes a call to the ROM BIOS. We suggest that you write a beep routine to use in your code. You can use the Beep routine from the PC or AT ROM BIOS for a guide, varying the sound, frequency, and timing until you're satisfied. In the section of the PC or AT Technical Reference *(older ones) devoted to source code for the ROM, you'll find a Beep routine. Use this code snippet in your own code. Another way to go about it is to install your own sound device driver to control the sound chip. Send messages from your code to the device driver (the same driver for all machines) to control tone (you can make the IBM thud instead of beep) and vary duration (but not, alas, volume). Or you might write a TSR that intercepts calls to the ROM BIOS for video output and checks for the bell character's being sent to the Write TTY function. Rather than invoke the ROM BIOS, invoke your own code.—Ed.* ♦

...of thought.

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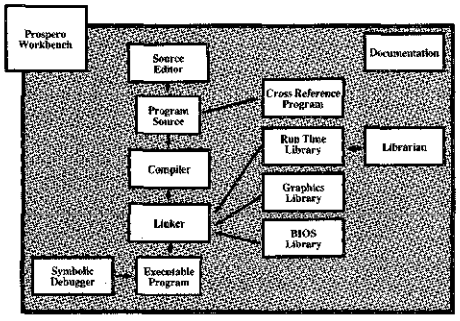

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Job-shopping

Almost Consulting

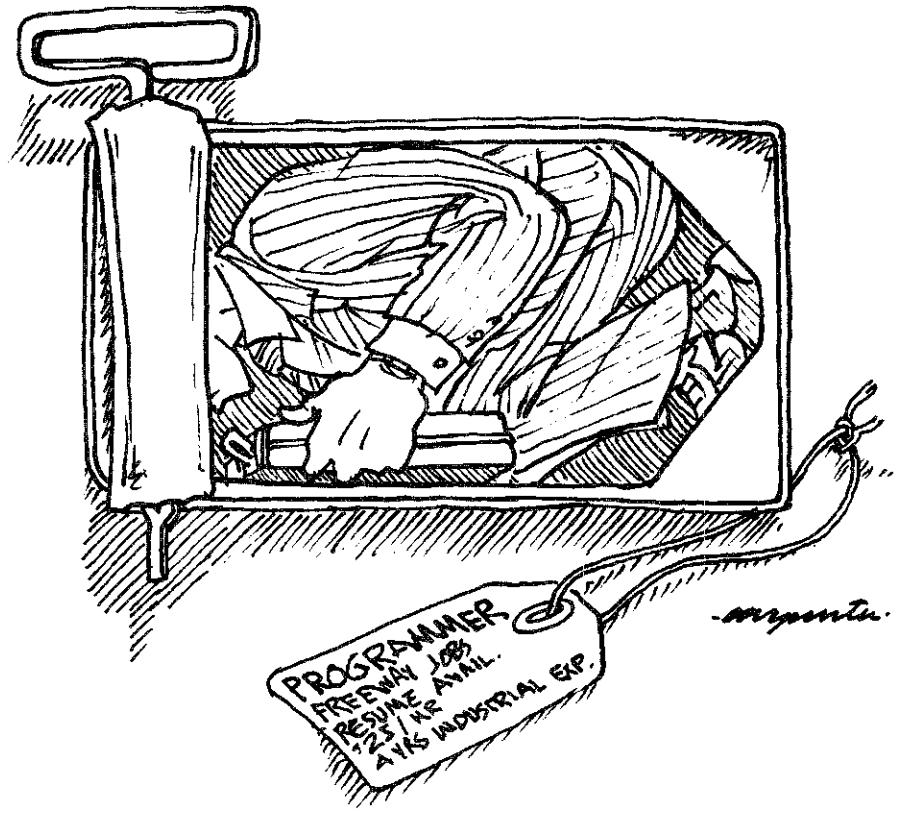
by
Oleg Panczenko

Paul Barkley's articles on consulting have long fueled readers' aspirations to go out on their own. But an employee's life is comfortable, and a consultant's responsibilities so intimidating that most don't advance beyond daydreaming. I, too, just daydreamed until fortune propelled me towards what I really wanted to do.

Two years ago I'd left a solid, if spiritless, company to work for a small start-up enterprise. I had stock options, and the company promised to be another Lotus.

The enterprise went bankrupt at the beginning of 1987.

My severance pay wasn't enough to pay for a trip around the world, but it was enough to settle all my debts. I figured this was a good time to try my hand at independent work. What kind of work can you do if you're too dumb to be a consultant but smart enough to work for yourself? Drawn by the prospect of earning $30 to $40 an hour, I decided to try my hand at *job-shopping*.



What Is Job Shopping?

As a job-shopper you're also called a freelance employee, contract employee, or technical professional. You are a master of some particular aspect of a profession for which you are highly paid. A job-shopper can go into a company on short notice, do a job, and leave. Job-shoppers work both for small companies and for big companies such as IBM, Bell Labs, Boeing, American Express, and Chemical Bank.

A number of sound reasons motivate a company to hire an expensive temporary employee rather than an inexpensive permanent one: First, it takes several weeks and quite a bit of money for a company to find a full-time employee. If a job has to be done immediately, a job-shopper can be found and hired within days. Second, the job may be a one-time service and the company have no need for a full-time employee to perform that particular service. Third, no company wants to fire people when business is slow. A company can hire contractors when times are good and let them go when times are tight without creating uncertainty or ill-will among its permanent employees.

A job-shopper trades a willingness to put up with uncertainty and to stay flexible for money. The shopper can be hired or fired at a moment's notice, and on a few day's notice may relocate to another state. Those willing to go anywhere there is work are said to prefer *road jobs*. This kind of shopper may get a weekly living allowance (the misleadingly named *per diem*) and travel pay. The client decides to hire this kind of shopper on the basis of his or her resume and perhaps a phone interview.

Those who prefer work within commuting distance can get *freeway* jobs. This is quite practical in urban areas such as Boston, Chicago, Houston, Los Angeles, San Francisco, and New York City. The rates for freeway jobs may be lower than those for road jobs. For freeway jobs, it's likely that the client will want a face-to-face interview. A freeway shopper works to establish a reputation with a set of local clients so that he or she may go from one to the next, assured of more or less constant employment.

Brokers

As a contract programmer you are a temporary hourly employee of a contract service firm, also called a *job-shop*. You announce yourself to a shop, which tries to match your skills with the requirements posted by the shop's clients. Many shops do nationwide placement: Just because the shop is local doesn't mean that it places only locally. Some shops will screen you: Their recruiters will call you in for a face-to-face technical interview or arrange one over the phone. Other shops will go on the basis of the recommendations made by your references. Some go strictly by your resume.

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The shops make their money under one of two basic types of arrangements with clients. The first is the *cost-plus* arrangement, where the client pays the hourly rate paid the programmer plus a mark-up for the shop's costs and profit. If you get $20 an hour and the shop charges a 25% mark-up, the shop bills the client $25 an hour. The incentive is for the shop to get the job-shopper as high a rate as it can. The other type of arrangement is *fixed price*. The shop contracts with a client to provide programming services for a given amount per unit time. The shop's profit then depends on how little they can get away with paying you.

No matter what kind of agency you deal with, none will charge you fees. Run, do not walk, from any agency that wants money from you.

The shop, not the client, pays you. The shop deducts FICA, federal and state taxes, social security, unemployment insurance, and any other deductions from your gross earnings. The shop will either mail you your check or you may pick it up at their offices. At the end of the year the shop will mail you your form W-2.

How Much Is Your Time Worth?

I've mentioned that you may expect between $30 and $40 an hour. But these big bucks are not so big. A regular job also provides you with benefits. Some contracting firms do offer vacation pay, insurance, and a retirement plan (401K) and may even have profit sharing. But all this comes after you've worked as a contractor for a while. When you're a beginner, the only thing your employer gives you is money. You have to provide your own health insurance (look into an HMO), life insurance, and retirement fund. You can delay consideration of some of these concerns, but not for too long. It takes the better part of a life to provide enough for old age. You have to work at least ten years at a company before you become vested in their pension plan. Bearing this in mind, you have to first calculate what is the true value of your time as a regular (also called *direct*) employee before you can figure out what your time is worth. As a rough guide, use this formula: Your rate should equal your present salary times the sum of 1 plus your benefits expressed as a fraction of your salary, all divided by the product of the fraction of a year you'll be working times the number of working hours in a year (2080).

For example, if your salary is $33,000 a year and your benefits are worth 33% of your base pay and you expect to be working nine months out of the year as a contractor, you would have to earn over $28 an hour as a contractor just to break even.

The rate you're paid depends on many factors. In the Northeast and California, expect $35–$40 an hour. In the South, expect $30–$35 an hour. If you have a security clearance, you can get $40–$45 an hour from the aerospace industry in the Pacific Northwest. These rates are approximate. I've had offers as low as $20–$25 an hour. My minimum is $30 an hour. Your rate also depends on the market, your experience, the demand for your skills, the duration of the contract (short ones usually pay more), location, cost-of-living in a given area, etc. Many recruiters are friendly and willing to talk. Don't be afraid to ask them about the range of going rates, the market, and what skills are hot.

Now, under Section 1706 of the Tax Reform Act of 1986, job-shoppers are considered to be temporary hourly employees of the brokers.

Getting a Fair Day's Pay

Ask about the following when you inquire about a job:

- The duration of the assignment. Some may be as short as a month; others may last several years. Most fall between six months and a year.
- The rate for the job. Your rate of pay may be stated in hourly, daily, or weekly terms. The daily and weekly rates assume a fixed amount of time spent each day or week. Ask what that amount is. Convert the figure to rate per hour.
- Overtime and the overtime rate. Some places pay straight time for overtime, others time-and-a-half.
- The frequency of payment: weekly, fortnightly, monthly.
- Special rates for worked holidays.
- Raises if the contract is to run for a year or more. When? How much?
- Mileage allowances if the job is further than 50 miles from home.
- Travel allowances and *per diems* if you must relocate. The *per diem* typically ranges between $50 and $120 a week. The client will usually pay for one-way transportation.

1706 and Taxes

In the past, the job-shopper was an independent; the job-shop acted only as a broker. Job shoppers were self-employed and could take normal business deductions from their taxable income. Now, under Section 1706 of the Tax Reform Act of 1986, job-shoppers are considered to be temporary hourly employees of the brokers. Brokers are lobbying for a repeal of this section of the tax law. With all the legal and political goings-on, the status of Section 1706 is in flux. Ask your shop for the latest information about 1706. Mr. Michael J. Wallach, who is associated with the Independent Computer Consultants Association (ICCA), welcomes calls from anyone interested in Section 1706. Call him at (718) 317-1813. By the time you read this, the ICCA should have a service in place that will send non-members information and news about 1706 for a nominal fee to cover copying and mailing costs.

What's the Work Like?

Expect what you're used to. Some places treat you just like an employee; the pressure, or lack of it, independent of the fact that you are a contractor. Some supervisors are relaxed and informal with contractors; others apply the sit-on-their-necks method of personnel motivation.

You'll find all the pathologies you find in the direct world. Some employers will tell you to waste no time designing or documenting: You are to crank out code, period. Others are too busy to tell the man they're paying $40 an hour what to do. There are those who are pleased with whatever you propose to do yet are never satisfied with what you've done.

Risks and Failure

There is a price for knowledge, and it's going to cost you something to find out if you can make a living as a job-shopper.

There will be a period of uncertainty about the future. Be prudent—spend less money. Uncertainty and your sudden frugality may strain personal relationships.

Come up with a cut-off date. After this date, begin a parallel search, looking for both contract and direct work. Give yourself six months to find contract work. Remember that it takes from six months to a year to find a good, regular full-time job. You may have

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JS, Oak Ridge, TN

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some difficulty returning to the world of direct work. Some employers think that someone who's demonstrated a taste for the independent life can't become a "team player."

Before You Try Job-shopping

Don't think of job-shopping unless you have lots of money set aside. You should have enough money to sustain yourself for at least six months. Take unemployment benefits into account.

Before you start, get rid of debt. I was fortunate in that my severance pay was sufficient to pay off my obligations.

Easy-to-anticipate obligations are rent, utilities, loan payments; the gotchas are the easy-to-forget semi-annual or annual payments for things such as

- auto insurance
- auto repairs and maintenance
- other insurance premiums (health, renter's)
- postal-box rental

Other common payments will increase once you become a shopper:

- Phone bills—these will go up even though some shops have toll-free numbers or will accept collect calls. Assume $30–$50 a month extra.
- Postage, envelopes, copying costs. Assume $25 a month.

Some new expenses will be printing costs for resumes and the costs of using your car or train fare if you are interviewed by local shops.

Looking for Work

Looking for work is full-time work. A typical workweek starts on Sunday. Get the paper and look for agencies. On Monday mail out resumes. Get on the phone and begin calling the agencies you mailed out resumes to the previous Monday. Then make follow-up calls to agencies that received your resume the previous month.

Preparing Your Resume

A good resume is more important when you are seeking contract work than when you are looking for a direct job. Often you will get your job on the basis of only your resume—no interviews and no personal meetings.

There are books full of resume formats. In general, have your name, address, and phone number at the top, then your title (programmer, software engineer), then a paragraph describing your strengths. *Presume that this paragraph is all that the busy recruiter will glance at.* Use a telegraphic style and state the languages, operating systems, hardware, software products, databases, and utilities that you know well. Describe your skills, such as product development, documentation writing, specifications writing. Follow with your work experience: Briefly but in detail describe what you did or learned at each job. Put yourself in the place of a client. Ask "what can this guy do for me?" When you prepare a history of your contract work, include the date of the assignments, but place them in such a way that they may be unobtrusively whitened out. Some agencies want workdates—others don't. This method accommodates both.

Typeset or laser print your resume. A resume set up typographically draws a busy reader's attention to what is most important. Use boldface for key words such as languages, hardware, special knowledge (linear algebra, for example). Don't go font-happy: A clean resume will be read; a rococo resume won't be.

Don't bother with cover letters—no one is going to read them.

Typesetting costs about $40 per page. Your typeset copy can be delivered as either the original (suitable for offset printing) or a PMT copy (suitable for bond-type copiers). A PMT copy is printed on a sheet of white plastic. (Sometimes exposure to strong light, as during copying, causes the PMT page to brown. This brown film is a photosensitive residue easily rinsed off.)

A word processing service with a laser printer can produce a resume that looks almost a good as one that is typeset—for less money. Many printers offer this service. Look for the tags "Laser Typesetting" or "Desktop Publishing." Typical fees are $25 for the first page of a resume and $5 each for succeeding pages.

Note that copying costs are extra.

Don't bother with cover letters—no one is going to read them.

Where to Send Your Resume

You can find addresses of job-shops in the special publications for contract engineers, in large-city newspapers, and in the yellow pages of the phone book.

I subscribed to *Contract Engineer Weekly* (C.E. Publications, Inc., P.O. Box 97000, Kirkland, WA 98083, 206/823-2222; $45 for 52 issues, $3 for a single copy), which covers the entire contract engineering industry, not just programming or software. With your subscription you get a *Directory of Contract Service Firms*. C.E. Publications also provides services such as typesetting, printing, and mailing of resumes, which I found to be satisfactory and competitively priced. Don't buy their video *Highway to Success*—it's superficial.

In the newspaper under "Programmers," look for ads with captions such as "$600/DAY" or "$10,000/MO" or "CONSULTING," or "HI $$$/DAY," or "FREELANCE EMPLOYEES."

Look in the yellow pages under

- "Employment Agencies"—in the ads look for "Temporary Division" or "Permanent/Temporary/Part Time."

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- "Employment Contractors/Temporary Help"—look for "Technical—Job Shop" in the ads.
- "Employment, Temporary."

Most of the agencies you find in the phone book will deal with jobs such as Accounting, Data Entry, Mail Clerking, Stock Picking, and Word processing, but a few agencies mention technical jobs in their ads.

If your employer hires job-shoppers, ask one of them for advice.

Some agencies acknowledge the receipt of your resume with a postcard or letter; others will call; about 50% won't acknowledge at all.

Follow-up Calls

Make follow-up calls—they're important. Some recruiters have little idea of what they are working with. I had to correct one recruiter's pronunciation of technical words and infer from what he stumbled through what the requirements of a particular job were.

Shops mechanically match the buzzwords in your resume with the buzzwords in the requirements submitted by the client. Often a client's requirement and your qualification fit but are described in slightly different terms—something a mechanical correlation won't match. Some qualifications are not imperative, and you may be strong in other areas: The client will accept you even though you are not an exact match. Remember, it's unlikely that clients will get exactly what they want: They have to settle for what they can get. Talk to a recruiter to find out what really matters and persuade the recruiter to send your resume for consideration. At the very least when you call, the recruiter pulls out your resume—in sight, in mind.

Keep records. I use a 3 x 5 card with the name, address, and phone number of the shop. I add the name of a contact, the dates I mailed resumes, when the shop replied (card or call), and when I placed follow-up calls.

Do You or Don't You Have a Job?

Eventually, you'll happen on a match of requirements and qualifications. You'll have a phone interview with the client. Then you'll wait for a reply. Most agencies won't call you to tell you that you've not gotten a job.

Be prepared to begin work on short notice. You may be interviewed by the shop Tuesday, by the client Wednesday, and begin work Friday!

Accept only jobs where you know the work unless the employer agrees in advance that you will spend some time learning—an assignment is not an occasion for on-the-job training.

What to Do When You Get the Job

After you've accepted the job, request a confirming letter or telegram containing (1) your hourly rate, (2) to whom you should report on the first day of work and his or her phone

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* March 10, 1987 issue, page 278.

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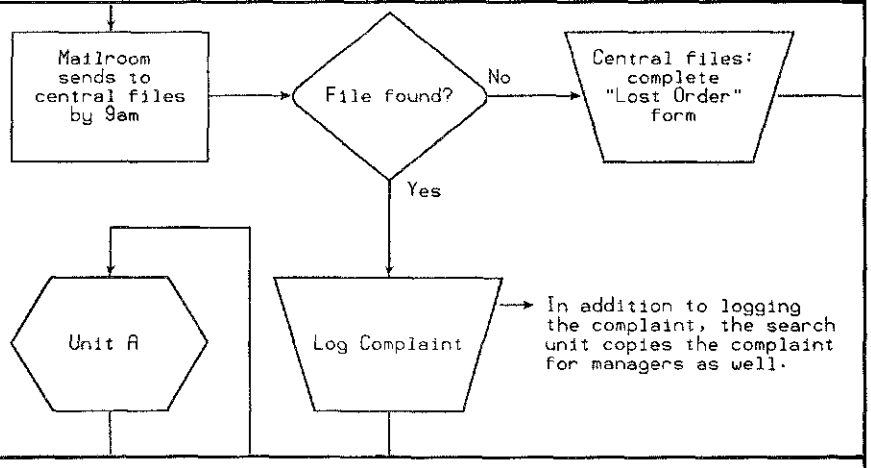
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SemWare Announces QEdit Advanced the "quick editor"

QEdit is one of the smallest, fastest, multi-file editors available for IBM compatible computers and has many features to enhance your productivity.

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- Edit multiple files, as many and as large as available memory allows. QEdit can use all available memory, up to 640KB. Ideal for multi-file languages and all those .PRG files.
- Windowing allows up to 7 files or 7 views of the same file to be seen at once.
- You do not have to "learn" another editor with QEdit. QEdit's commands can be configured to any keys you like.
- Screen colors, tab settings, default file type and many other options can be configured the way YOU like it.
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What's Hot

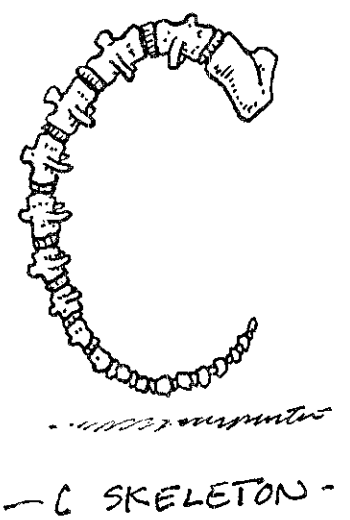
In my experience what's hot here in the Northeast is C/Unix, Unix internals, MS Windows, X Windows, LANs (Local Area Networks), PL/1, and database, particularly dBase, with C.

Conclusion

Don't quit your job to become a job-shopper. If what I've described appeals to you, wait until a time when you would naturally separate from your employer—then give job-shopping a try. Consider using job-shopping as a way of trying several companies before selecting one to settle down with.

If you are interested in working on your own, but aren't ready to be a consultant, job-shopping may be right for you. ♦

Oleg Panczenko, a software engineer, got his first programming job in 1979 after submitting a hand-written resume to his prospective employer. He has modeled ink jets, maintained a semiconductor-laser parameter database, programmed for a coordinate measuring-machine manufacturer, and worked on the user interface of a database product. Oleg spent 1987 job-shopping, then returned to direct work.



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Windowing Systems Overview

by
Frank D. Greco

Nowadays it seems that most commercial end-user applications running on a DOS-OS/2 powered PC or Unix workstation use a formal window system—Microsoft Windows or X Windows—or at the very least some sort of pop-up/pull-down/pull-across menu-based user interface. As we move into the momentous era of multitasking and multi-MIP microcomputers with huge monitors, a window system model would seem to be mandatory.

Unfortunately, a standard window system still eludes us. From the personal computer world we have products such as Microsoft's Windows, its OS/2 manifestation the Presentation Manager, Digital Research's GEM, and Apple's now-ubiquitous Macintosh interface—each with its own array of installed customers and applications. On the Unix side, we have very sophisticated network-based systems such as MIT's X Windows, Silicon Graphics' 4Sight, Carnegie-Mellon's Andrew, and Sun Microsystems' NeWS. Right now, none of these disparate window systems can be considered truly standard.

Window Pains

None of these systems provides a clear or clean answer to the user interface question. Microsoft's Windows/Presentation Manager has been criticized for its unwieldiness (450 library calls). It appears to be the product of committee design and occasionally lacks an intuitive feel. I know of several large companies who just gave up on MS Windows because of its complexity.

The Apple Macintosh interface is much admired, but it is not truly multitasking and is proprietary to say the least.

While it's very easy to use, GEM lacks the backing of a major software house.

X Windows requires a multitasking operating system such as Unix, and it can't handle kerned fonts—a major flaw. Until Adobe Systems' Display PostScript is incorporated into X Windows, WYSIWYG products that use kerned outline fonts can't be built. How Display PostScript will be incorporated into X Windows has yet to be determined. And I have yet to see an X Windows application that equals the visual aesthetics of a Macintosh application. Any window system that hopes to be universally accepted must *at least* look as good as the Macintosh interface.

Programming for Sun's NeWS requires knowledge of PostScript. And while NeWS has the technical potential for success, it does not yet have a rich programmer toolkit, a requirement for any successful user interface.

The Origins of Windows

While the popularity of using windows can plausibly be attributed to the Apple Macintosh, Dan Ingalls came up with the original concept of splitting up the physical screen into separate areas called windows at Xerox's Palo Alto Research Center (PARC). This was in the early 1970s, and windows were developed for use in the Smalltalk environment. The invention of the mouse by Doug Englebart (who also invented the word processor) in the 1960s also contributed to the popularity of a windows interface. And I.E. Sutherland developed the direct man-machine graphical interface with his Sketchpad, a prototypical MacPaint/MacDraw system circa 1963. It is the combination of these three major innovations that has made window systems so successful.

When Is a Window Not a Window?

It should be noted (and has been noted in my Redirections column before) that the term "window" is actually used somewhat incorrectly in the popular computer literature. The term "window" in the standard computer graphics sense refers to a rectangular area of interest in the real-world coordinate space that the programmer/user wants to display. A section of screen real estate that maps this area is called a "viewport," but in everyday computer parlance, the term "window," rather than "viewport," has become more associated with a section of screen. This unfortunate association gets confusing and cumbersome when graphics libraries (such as PHIGS+ or GKS) are implemented over a window system. Recognizing this ambiguity, Sun Microsystems has come up with yet another word for a segment of the screen—Sun calls a segment of the screen a "canvas" (yet they don't talk about "canvas management" in their documentation!).

The Architecture of a Window System

From my perspective, a window system is composed of four basic layers:

- User interface/application layer
- Programmer toolkit
- Management and synchronization of screen real estate
- Image rendering model

The user interface layer defines the application's so-called "look and feel." How scroll bars react to mouse events, how a window is made iconic, methods of resizing a window, etc., are all components of this abstraction level. The programmer toolkit is the collection of software primitives used to implement any particular user interface. The next lower level is the screen management layer—the heart of the window system. The management layer is responsible for interpreting incoming information from the toolkit layer (through either the stack or a more formal protocol) and for mediating access among processes or pseudo-processes to the physical screen. The rendering model is the layer that finally puts graphical images, color or monochrome, onto a physical screen.

Most window systems that currently run with the help of the Unix operating system have layers defined that clearly. For example, Sun Microsystems' NeWS rendering model is PostScript. Its management layer is called the NeWS server. One possible programmer toolkit for NeWS is called the NeWS Development Environment (NDE). One possible user interface that you can build using NDE is called "Open Look." The X Windows system uses similar design layers.

The architecture of PC-originated window systems, on the other hand, is not so clearly stratified. Besides being a base window management system, Microsoft Windows already predefines the user interface and interface toolkit. So does Apple's Macintosh. This forces the programmer to use only a single "look and feel" application interface. Such a restriction can be an asset if the user interface is a good one; witness the tremendous success of the Mac interface (especially with non-computer types). Digital Research's GEM doesn't define a user interface layer at all. Using the same GEM

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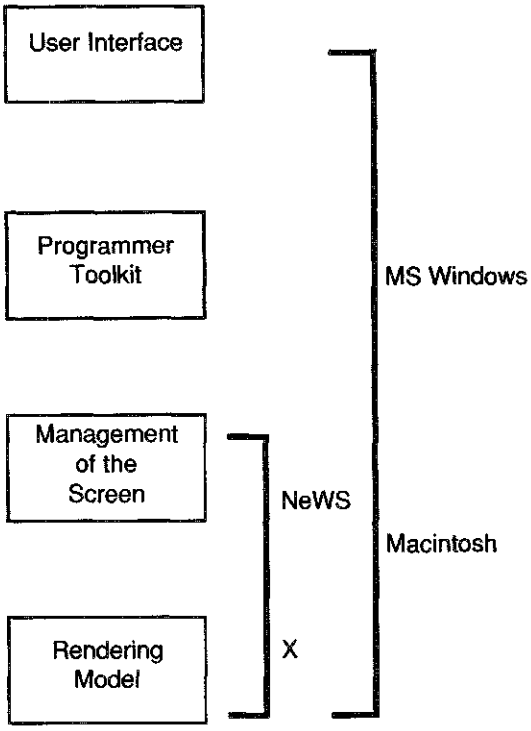

programmer toolkit available from Digital Research, a developer can create quite different "look and feel" interfaces.

Not having clearly separate layers of responsibilities makes it difficult to wrench the programmer toolkit from either MS Windows or the Mac and port it to another windowing environment. Microsoft CEO Bill Gates is making a pitch to persuade the Unix-based X/Open organization to use the Presentation Manager as the standard Common Application Environment for Unix applications. I doubt he will succeed. Besides Unix-related political problems with IBM and concerns regarding putting the Presentation Manager specification into the public domain, *cleanly* separating the Presentation Manager programmer toolkit from the rest of the window system won't be easy. Notice that Apple is not exactly having an easy time porting the Macintosh interface over to A/UX (rumor has it that most of this work is based on the exclusively licensed software from the now-defunct Cadmus corporation).

A Very Sybil Window System

In addition, MS Windows also attempts to be a crutch for MS-DOS in its quest to be a real operating system (by definition, an operating system must have process management, which MS-DOS does not have). MS Windows manages memory, does (cooperative) multitasking, mediates resources, performs message passing interprocess communication, revectors INT 21H and many BIOS entry points—in short, it's trying to be the operating system that MS-DOS isn't. Not only are its architectural responsibilities confusing, but Microsoft also can't make up its mind whether the system should be called Presentation Manager or Windows. "Well if it uses OS/2, call it Presentation Manager; otherwise, call it Windows . . . Windows is virtually identical to PM." Heck, just call it one thing or the other!

You've Got the "Look"

When you hear that NeWS and X Windows will provide a standard look to all Unix applications, understand that that's not entirely correct. By definition, both NeWS and X Windows are window systems, not user interfaces. Recently, AT&T and Sun have made news by jointly announcing the availability of the "Open Look" Xerox PARC-style (bet you thought I was gonna say "Mac-style") user interface specification. Sun developed the Open Look specification with licensed help from Xerox (and has implemented a prototypical version), and AT&T will license implementations of the specification as commercial products. While not revolutionary, the Open Look specification represents a consistent "look and feel" for Unix application software. In fact, the specification of Open Look does not require any particular window system or operating system as the underlying engine and can be implemented even in an OS/2 environment. According to AT&T, first drafts of the specification will circulate among developers in July.

Work is now underway to develop programmer toolkits to assist in building Open Look. The X Windows toolkit, called "Xt," is available on the core distribution tape from MIT. Other higher level toolkits for X Windows, such as the Andrew toolkit from Carnegie Mellon University, Xrlib from Hewlett-Packard, and Interviews from Stanford University, are available on the user contributed tape from MIT. Each tape costs $200 and includes all source code. The NeWS toolkit, NDE, is an object-oriented toolkit in the Smalltalk tradition currently under development at Sun Microsystems. Because of a large installed base of application programs, Sun is also working on an enhanced toolkit for their older and archaic SunView proprietary window system so that it can support Open Look.

The Central Part of a Window System

The heart of a window system lies in its mechanism for interpreting communication between and within active processes and mediating access to the physical screen.

Microsoft Windows does this through its GDI (Graphics Device Interface) and USER modules. The third module in MS Windows, the KERNEL module, basically handles process (co-routine) management and memory management. MS Windows function calls are Pascal-flavored functions that call one of the three basic modules, which invokes either a Windows device driver or an operating system function. The communication "protocol" used by MS Windows is simply the standard use of the stack. I'm not yet convinced that the choice of a Pascal calling sequence for MS Windows functions is a good idea.

Gotta Network Yourself These Days

As opposed to the Macintosh and MS Windows systems, both X Windows and NeWS are server-based, networkable window systems. This does not mean that programs that obtain information over a network can't be built with MS Windows or the Macintosh. Quite the contrary—some very innovative network-based programs can be built with the Macintosh and MS Windows. A network window system just implies that networking applications can be built much more easily because a network is a natural constituent of the window system.

A (redirectable) network window server is logically "connected" to a workstation's screen and communicates with application clients anywhere on the network. Unlike traditional servers, as in a file server, window servers exist in every workstation that requires the rendering of graphical images. X Windows clients talk to the X server via a numerical high-level protocol (the X Protocol) that is generated through the X library. The NeWS protocol is an interesting one. NeWS clients talk to the NeWS server by sending PostScript program segments to it. In effect, you are downloading a program when you communicate with a NeWS server. The use of PostScript gives you the advantage of an effective communications

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```
resetprn.lst    ResetPRN v1.01                Sourcer Listing    19-Apr-88   4:05 pm      Page 1

                                PAGE  60,132
                                ;-----------------------------------------------------------------
                                ;                          RESETPRN
                                ;
                                ;       Created:   15-Apr-88
                                ;       Version:   1.01
                                ;-----------------------------------------------------------------

= 0008                          data_1e         equ     8               ; (0040:0008=378h)

                                ;---------------------------------------------------- seg_a -----
                                seg_a           segment para public
                                                assume cs:seg_a, ds:seg_a, ss:stack_seg_b

                                resetprn        proc    far
                                start:
658E:0000                       ;
658E:0000  EB 23                                jmp     short loc_1
658E:0002  52 65 73 65 74 50                    db      'ResetPRN v1.01', 0Dh
658E:0008  52 4E 20 76 31 2E
658E:000E  30 31 0D
658E:0011  0040                 data_2          dw      40h
658E:0013  0D 0A 52 65 73 65    data_3          db      0Dh, 0Ah, 'Reset Printer? $'
658E:0019  74 20 50 72 69 6E
658E:001F  74 65 72 3F 20 24
658E:0025                       loc_1:
658E:0025  0E                                   push    cs
658E:0026  1F                                   pop     ds
658E:0027  BA 0013                              mov     dx,offset data_3  ; (658E:0013=0Dh)
658E:002A  B4 09                                mov     ah,9
658E:002C  CD 21                                int     21h             ; DOS Services  ah=function 09h
                                                                        ;  display char string at ds:dx
658E:002E  B4 01                                mov     ah,1
658E:0030  CD 21                                int     21h             ; DOS Services  ah=function 01h
                                                                        ;  get keybd char al, with echo
658E:0032  3C 79                                cmp     al,79h          ; 'y'
658E:0034  75 16                                jne     loc_3           ; Jump if not equal
658E:0036  8E 1E 0011                           mov     ds,data_2       ; (658E:0011=40h)
658E:003A  8B 16 0008                           mov     dx,ds:data_1e   ; (0040:0008=378h)
658E:003E  83 C2 02                             add     dx,2
658E:0041  B0 08                                mov     al,8
658E:0043  EE                                   out     dx,al           ; port 37Ah, printer-2 control
                                                                        ;  al = 8, initialize printer
658E:0044  B9 8000                              mov     cx,8000h
658E:0047                       locloop_2:
658E:0047  E2 FE                                loop    locloop_2       ; Loop if cx > 0
658E:0049  B0 0C                                mov     al,0Ch
658E:004B  EE                                   out     dx,al           ; port 37Ah, printer-2 control
                                                                        ;  al = 0Ch, init & strobe off
658E:004C                       loc_3:
658E:004C  B4 4C                                mov     ah,4Ch          ; 'L'
658E:004E  CD 21                                int     21h             ; DOS Services  ah=function 4Ch
                                                                        ;  terminate with al=return code
                                resetprn        endp
                                seg_a           ends

                                ;---------------------------------------------------- stack_seg_b ----
                                stack_seg_b     segment para stack
6593:0000  00C0[ff]                             db      192 dup (0FFh)
                                stack_seg_b     ends

                                                end     start
```

(Source code output and inline cross reference can also be selected)

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X Windows versus NeWS

While the notion of a window manager is inseparable from the design of MS Windows, both X Windows and NeWS are structured so that window managers are seen as just another window system client application. Several types of window managers can be written for either X or NeWS. This separation of window placement policy from management of the screen real estate is an interesting idea. Such a distinction means that different types of window managers—tiled or overlapping, for instance—can be implemented as user programs that communicate with the window system server. X Windows, however, assumes that windows can be rectangular only; NeWS doesn't make that assumption. A window in X Windows also requires the use of an expensive Unix heavyweight process. Since NeWS uses lightweight processes (unfortunately, nonpreemptive, as in MS Windows), the creation of a window in NeWS is very fast and cheaper in terms of resources. X Windows requires a multitasking operating system. NeWS is implemented as one heavyweight process and so can be implemented on a single-tasking operating system. In fact, besides running on Unix machines, NeWS is currently running on the Atari and the Mac.

Windows of Opportunity

I've only touched the surface of what window systems are and how they work. It's very clear that window systems and graphical user interfaces will be the norm on most computer architectures in the near term future (that was clear years ago). Given that we will shortly have 100 MIP workstations on the desktop, who knows what the next viable user interface will be. Ain't this fun?

Before I Go, a Soapbox to Remember Me by

The Macintosh's user interface has been the standard by which every other interface is judged, and this is unfortunate in certain respects. If we aspire merely to the familiar, the level of user interface sophistication will remain frozen at the Macintosh level. While the Macintosh interface is currently one of the most intuitive graphical user interfaces for computers, it surely is not the last word in man-machine interaction. ♦

Frank D. Greco is an independent consultant who does industry analysis, systems consulting, and technological forecasting for Fortune 500 companies. Readers can contact Frank at the following address:

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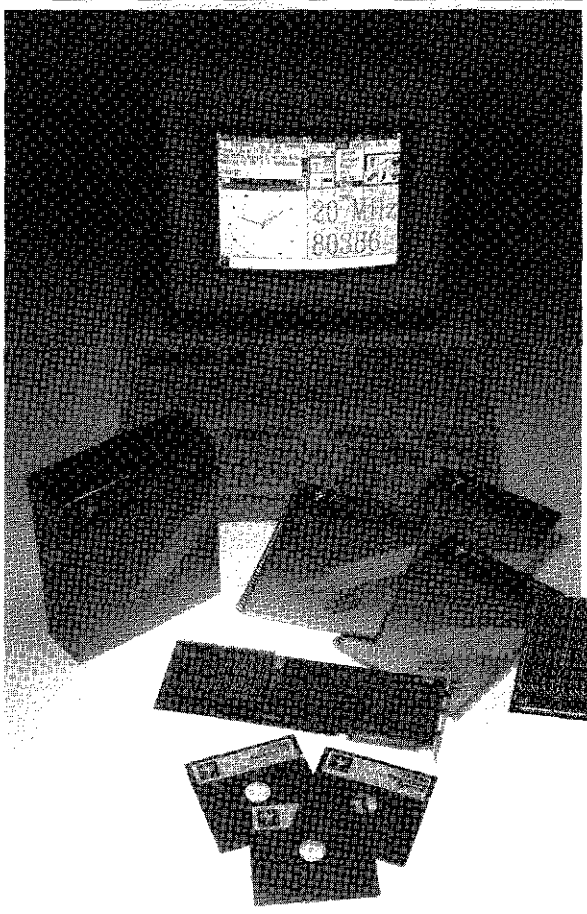

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Reading VGA Memory

by
Michael Abrash

Installment 7: In which we learn to read VGA memory and encounter the strange but useful Color Compare.

Well, it's taken six installments of On Graphics, but we've finally covered all four write modes of the VGA. Now it's time to tackle the VGA's two read modes. While the read modes aren't as complex as the write modes, they're nothing to sneeze at. In particular, read mode 1 (also known as color compare mode) is rather unusual and not particularly intuitive.

You may well ask, isn't *anything* about programming the VGA straightforward? Well . . . no. But then, clearing up the mysteries of VGA programming is what these articles are all about, so let's get started.

Read Mode 0

Read mode 0 is actually relatively uncomplicated, given that you understand the four-plane nature of the VGA. (If you don't understand the four-plane nature of the VGA, get your hands on *PJ* issues 5.1–5.4 and 6.1–6.2.) Read mode 0, the read mode counterpart of write mode 0, lets you read from one (and only one) plane of VGA memory at any one time.

Read mode 0 is selected by setting bit 3 of the Graphics Mode register (Graphics Controller register 5) to 0. When read mode 0 is active, the plane that supplies the data when the CPU reads VGA memory is the plane selected by bits 1 and 0 of the Read Map register (Graphics Controller register 4). When the Read Map register is set to 0, CPU reads come from plane 0 (the plane that normally contains blue pixel data). When the Read Map register is set to 1, CPU reads come from plane 1; when the Read Map register is 2, CPU reads come from plane 2; and when the Read Map register is 3, CPU reads come from plane 3.

That all seems simple enough; in read mode 0, the Read Map register acts as a selector among the four planes, determining which one of the planes will supply the value returned to the CPU. There is a slight complication, however, in that the value written to the Read Map register in order to read from a given plane is not the same as the value written to the Map Mask register (Sequence Controller register 2) in order to write to that plane.

Why is that? Well, in read mode 0, one and only one plane can be read at a time, so there are only four possible settings of the Read Map register: 0, 1, 2, or 3, to select reads from plane 0, 1, 2, or 3. In write mode 0, by contrast (in fact, in any write mode), any or all planes may be written to at once since the byte written by the CPU can "fan out" to multiple planes. Consequently, there are not four but sixteen possible settings of the Map Mask register. The setting of the Map Mask register to write only to plane 0 is 1; to write only to plane 1 is 2; to write only to plane 2 is 4; and to write only to plane 3 is 8.

As you can see, the settings of the Read Map and Map Mask registers for accessing a given plane don't match. The code in Listing 1 illustrates this. Listing 1 simply copies a sixteen-color image from system memory to VGA memory, one plane at a time, then animates by repeatedly copying the image back to system memory, again one plane at a time, clearing the old image and copying the image to a new location in VGA memory. Note the differing settings of the Read Map and Map Mask registers.

By the way, the code in Listing 1 is intended only to illustrate read mode 0,

and is, in general, a poor way to perform animation since the method is slow and tends to produce flicker. In a future issue of *PJ*, I'll take a look at VGA animation techniques.

As you might expect, neither the read mode nor the setting of the Read Map register affects CPU *writes* to VGA memory in any way.

An important point regarding reading VGA memory involves the VGA's latches. (Remember that each of the four latches stores a byte for one plane; on CPU writes, the latches can provide some or all of the data written to display memory, allowing fast scrolling and efficient pixel masking.) Whenever the CPU reads a given address in VGA memory, each of the four latches is loaded with the contents of the byte at that address in its respective plane. Even though the CPU receives data from only one plane in read mode 0, all four planes are always read and the values read are stored in the latches. This is true in read mode 1 as well. In short, whenever the CPU reads VGA memory in any read mode, all four planes are read and all four latches are loaded.

Finally, before we go on to read mode 1, I'd like to note that the EGA

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supports slightly different versions of read mode 0 and read mode 1. The EGA's read modes are compatible with the VGA's read modes so long as you don't set bit 2 of the EGA's Read Map register to 1, and so long as you don't touch the EGA's Graphics Position registers (at ports 3CCh and 3CAh).

Read Mode 1

Read mode 0 is the workhorse read mode, but it's got an annoying limitation: Whenever you want to determine the color of a given pixel in read mode 0, you have to perform four VGA memory reads, one for each plane, and then interpret the four bytes you've read as eight 16-color pixels. That's a lot of programming; the code is also likely to run slowly, all the more so because the VGA takes an average of 1.1 microseconds to complete each memory read and read mode 0 requires four reads in order to read the four planes. (1.1 microseconds may not sound like much, but on an 8-MHz AT, it's 9 clock cycles, and on a 20-MHz Compaq 80386 machine, it's 22 clock cycles!)

Read mode 1, or color compare mode, provides special hardware assistance for determining whether a pixel is a given color. With a single read mode 1 read, you can determine whether up to eight pixels are a specific color, and you can even specify any or all planes as "don't care" planes in the pixel color comparison.

Read mode 1 is selected by setting bit 3 of the Graphics Mode register (Graphics Controller register 5) to 1. In its simplest form, read mode 1 compares the cross-plane value of each of the eight pixels at a given address to the color value in bits 3–0 of the Color Compare register (Graphics Controller register 2) and returns a 1 to the CPU in the bit position of each pixel that matches the color in the Color Compare register and a 0 for each pixel that does not match.

That's certainly interesting, but what's read mode 1 good for? One obvious application is in implementing flood-fill algorithms since read mode 1 makes it easy to tell when a given byte contains a pixel of a boundary color. Another application is in detecting on-screen object collisions, as illustrated by the code in Listing 2.

Still and all, there aren't all that many uses for basic color compare operation. There is, however, a genuinely odd application of read mode 1 that's worth knowing about; in order to understand that, we must first look at the "don't care" aspect of color compare operation.

As described above, during read mode 1 reads, the color stored in the Color Compare register is compared to each of the eight pixels at a given address in VGA memory. But—and it's a big but—any plane for which the corresponding bit in the Color Don't Care register is a 0 is always considered a color compare match, regardless of the values of that plane's bits in the pixel and in the Color Compare register.

There is a genuinely odd application of read mode 1 that's worth knowing about.

Let's look at this another way. A given pixel is controlled by four bits, one in each plane. Normally (when the Color Don't Care register is 0FFh), the color in the Color Compare register is compared to the four bits of each pixel; bit 0 of the Color Compare register is compared to the plane 0 bit of each pixel, bit 1 of the Color Compare register is compared to the plane 1 bit of each pixel, and so on; that is, when the lower four bits of the Color Don't Care register are all set to 1, all four bits of a given pixel must match the Color Compare register in order for a read mode 1 read to return a 1 for that pixel to the CPU.

But if any bit of the Color Don't Care register is 0, the corresponding bit of each pixel is unconditionally considered to match the corresponding bit of the Color Compare register. You might think of the Color Don't Care register as selecting exactly which planes should matter in a given read mode 1 read. At the extreme, if all bits of the Color Don't Care register are 0, read mode 1 reads will always return 0FFh since all planes are considered to match all bits of all pixels.

Now, we're all prone to using tools the "right" way—that is, in the way in which they were intended to be used. By that token, the Color Don't Care register is clearly intended to mask one or more planes out of a color comparison, and as such, has limited use. However, the Color Don't Care register becomes far more interesting in exactly the "extreme" case described above, where all planes become "don't care" planes.

Why? Well, as I've said, when all planes are "don't care" planes, read mode 1 reads always return 0FFh. Now, when you AND any value with 0FFh, the value remains unchanged, and that can be awfully handy when you're using the bit mask to modify selected pixels in VGA memory. Recall that you must always read VGA memory to load the latches before writing to VGA memory when you're using the bit mask. Traditionally, two separate instructions—a read followed by a write—are used to perform this task. The code in Listing 2 uses this approach. Suppose, though, that you've set the VGA to read mode 1, with the Color Don't Care register set to 0 (meaning all reads of VGA memory will return 0FFh). Under these circumstances, you can use a single AND instruction to both read and write VGA

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memory since ANDing any value with 0FFh leaves that value unchanged.

Listing 3 illustrates an efficient use of write mode 3 in conjunction with read mode 1 and a Color Don't Care register setting of 0. The mask in AL is passed directly to the VGA's bit mask (that's how write mode 3 works—see *PJ* 6.1 for details). Because the VGA always returns 0FFh, the single AND instruction loads the latches, leaves AL unchanged, and writes the value in AL to the VGA, where the value is used to generate the bit mask. This is faster, more compact, and more register-efficient than using separate instructions to read and write.

By the way, I commented in *PJ* 6.1 that I hadn't come across any particularly noteworthy applications for write mode 3. That's true no longer—Listing 3 shows how write mode 3 can make for excellent dot- and line-drawing code.

I hope I've given you a good feel for what color compare mode is and what it might be used for. Color compare mode isn't particularly easy to understand, but it's not that complicated in actual operation, and it's certainly useful at times; take some time to study the sample code and perform a few experiments of your own, and you may well find some useful applications for color compare mode in your graphics code.

A final note: The Read Map register has no effect in read mode 1, and the Color Compare and Color Don't Care registers have no effect either in read mode 0 or when writing to VGA memory.

Using Local Labels in REPT Blocks

I'm going to round out this installment with some odds and ends that have accumulated while I've been covering read and write modes. First, a truly annoying MASM 5.0 bug (at least, I think it's a bug): How the heck can I use local variables in REPT blocks? On page 223 of the MASM 5.0 manual I find the statement, "Macro operators, symbols declared with the LOCAL directive, and the EXITM directive can be used in repeat blocks."

Well, sure, the LOCAL directive can be used in a REPT block, and symbols declared with LOCAL can be used in repeat blocks—however, those symbols can't be used more than once in a given repeat block, which kind of defeats the purpose of using local symbols. I've also tried embedding REPT blocks inside macros and declaring symbols local in the macro, both inside and outside the REPT block, but that didn't work either. Listing 4 shows some of the approaches I've tried without success.

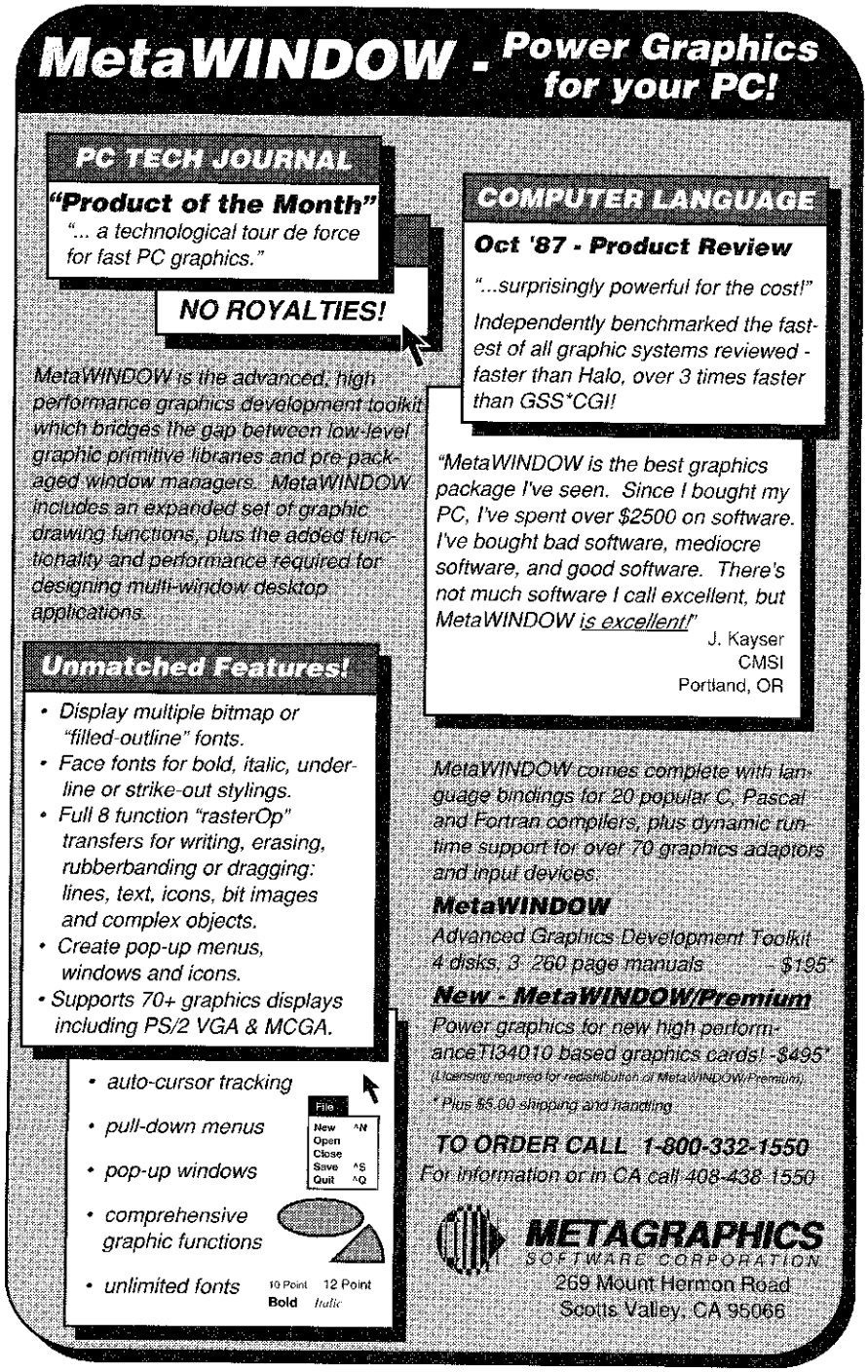
In the past, *PJ* readers have always come up with innovative solutions to the MASM problems I've encountered. Any help with this one would be appreciated, and would of course be shared with *PJ*'s readers.

Slow VGA Mode 13H Mode Sets

I've gotten reader feedback to the effect that mode 13h mode sets on IBM's VGA are extremely slow, to the point of interfering with code that performs frequent mode sets without clearing display memory (by way of setting bit 7 of AL high when invoking INT 10h, function 0). I haven't noticed this myself, but then I haven't done much work with mode 13h. Does anyone out there know more about this problem, and if so, do you have a workaround?

Reference Material

My primary reason for starting this On Graphics series was the then near-total absence of useful reference material on graphics adapters. That situation is now much eased by the appearance of Richard Wilton's excellent book, *Programmer's Guide to PC & PS/2 Video*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Systems, from Microsoft Press. [See Miscellaneous, *PJ* 6.3.—Ed.] I haven't read the entire book (sorry about that, but I do after all already know much of the subject matter), but the chapters I have read are accurate and readable and come with large quantities of sample code. The book covers all current graphics standards, including CGA, EGA, VGA, and Hercules, and does a good job of it. Simply put, *Programmer's Guide to PC & PS/2 Video Systems* is far and away the best PC graphics reference I've seen to date.

There is one flaw with Wilton's book, however, although I very much doubt it's the author's doing: The listings are typeset in pale green and are virtually invisible without good lighting. It's genuinely a shame that so much useful sample code should be so hard to read.

Video Image Capture

David P. Holberton wrote with an interesting question about the image-capture capabilities of the EGA and VGA: Can the EGA or VGA easily be modified to allow video images to be captured directly into EGA/VGA display memory?

I surely didn't know the answer—hardware is not my field—but I asked several hardware engineers, and they were unanimous in their opinion that any such change would require major surgery to the EGA or VGA board. (They were also unanimous in their opinion that while *they* could make such a change, they didn't recommend it for other people.) The feature connectors at the top of the EGA and Display Adapter boards (which are not identical, by the way) are useless for this purpose since they provide no path to display memory. In short, the answer seems to be no. However, David's question was sparked by a paragraph from page 640 of Nelson Johnson's book *Advanced Graphics in C*, so perhaps there's something we're missing here. Possibly the modification involved the EGA's memory expansion connector; however, that would be of limited use since very few EGA clones have memory expansion connectors. In any case, contributions on this topic are welcome.

In Conclusion

Gee, we're actually done with the basics of accessing VGA memory! Fortunately, that still leaves a slew of interesting VGA topics, such as multiple font support, multiple text pages, 43- and 50-line text, smooth panning and scrolling, the split screen, the vertical interrupt, and color selection—not to mention actual applications, including my personal favorite, animation. Frankly, I don't know just what I'll cover next time—tune in and find out. See you then. ♦

Michael Abrash is a Senior Software Engineer for Orion Instruments, Inc., of Redwood City, California, where he is working on the design of advanced PC-based test instrumentation. Readers may write to Michael at

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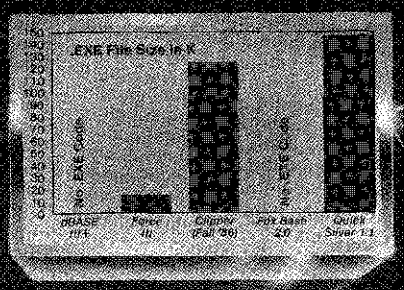

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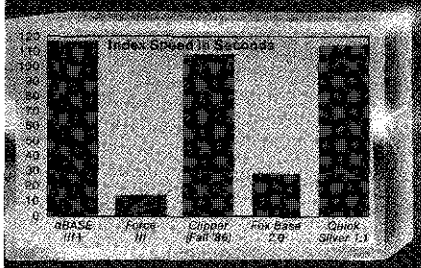

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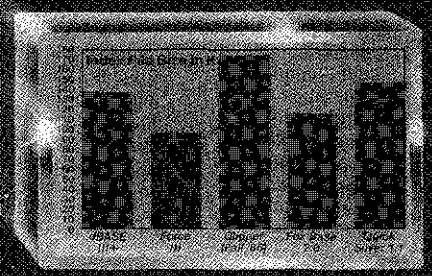

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Code from "Reading VGA Memory" by Michael Abrash

1

```
; *** Listing 1 ***
;
; Program to illustrate the use of the Read Map register in read mode 0.
; Animates by copying a 16-color image from VGA memory to system memory,
; one plane at a time, then copying the image back to a new location
; in VGA memory.
;
; By Michael Abrash 4/2/88
;
stack   segment word stack 'STACK'
        db      512 dup (?)
stack   ends
;
data    segment word 'DATA'
IMAGE_WIDTH     EQU     4       ;in bytes
IMAGE_HEIGHT    EQU     32      ;in pixels
LEFT_BOUND      EQU     10      ;in bytes
RIGHT_BOUND     EQU     66      ;in bytes
VGA_SEGMENT     EQU     0a000h
SCREEN_WIDTH    EQU     80      ;in bytes
SC_INDEX        EQU     3c4h    ;Sequence Controller Index register
GC_INDEX        EQU     3ceh    ;Graphics Controller Index register
MAP_MASK        EQU     2       ;Map Mask register index in SC
READ_MAP        EQU     4       ;Read Map register index in GC
;
; Base pattern for 16-color image.
;
PatternPlane0   label   byte
        db      32 dup (0ffh,0ffh,0,0)
PatternPlane1   label   byte
        db      32 dup (0ffh,0,0ffh,0)
PatternPlane2   label   byte
        db      32 dup (0f0h,0f0h,0f0h,0f0h)
PatternPlane3   label   byte
        db      32 dup (0cch,0cch,0cch,0cch)
;
; Temporary storage for 16-color image during animation.
;
ImagePlane0     db      32*4 dup (?)
ImagePlane1     db      32*4 dup (?)
ImagePlane2     db      32*4 dup (?)
ImagePlane3     db      32*4 dup (?)
;
; Current image location & direction.
;
ImageX          dw      40      ;in bytes
ImageY          dw      100     ;in pixels
ImageXDirection dw      1       ;in bytes
data    ends
;
code    segment word 'CODE'
        assume  cs:code,ds:data
Start   proc    near
        cld
        mov     ax,data
        mov     ds,ax
;
; Select graphics mode 10h.
;
        mov     ax,10h
        int     10h
;
; Draw the initial image.
;
        mov     si,offset PatternPlane0
        call    DrawImage
;
; Loop to animate by copying the image from VGA memory to system memory,
; erasing the image, and copying the image from system memory to a new
; location in VGA memory. Ends when a key is hit.
;
```

2

```
AnimateLoop:
;
; Copy the image from VGA memory to system memory.
;
        mov     di,offset ImagePlane0
        call    GetImage
;
; Clear the image from VGA memory.
;
        call    EraseImage
;
; Advance the image X coordinate, reversing direction if either edge
; of the screen has been reached.
;
        mov     ax,[ImageX]
        cmp     ax,LEFT_BOUND
        jz      ReverseDirection
        cmp     ax,RIGHT_BOUND
        jnz     SetNewX
ReverseDirection:
        neg     [ImageXDirection]
SetNewX:
        add     ax,[ImageXDirection]
        mov     [ImageX],ax
;
; Draw the image by copying it from system memory to VGA memory.
;
        mov     si,offset ImagePlane0
        call    DrawImage
;
; Slow things down a bit for visibility.
;
        mov     cx,1000h
DelayLoop:
        loop    DelayLoop
;
; See if a key has been hit, ending the program.
;
        mov     ah,1
        int     16h
        jz      AnimateLoop
;
; Clear the key, return to text mode, and return to DOS.
;
        sub     ah,ah
        int     16h
        mov     ax,3
        int     10h
        mov     ah,4ch
        int     21h
Start   endp
;
; Draws the image at offset DS:SI to the current image location in
; VGA memory.
;
DrawImage       proc    near
        mov     ax,VGA_SEGMENT
        mov     es,ax
        call    GetImageOffset  ;ES:DI is the destination address for the
                                ; image in VGA memory
        mov     dx,SC_INDEX
        mov     al,1            ;do plane 0 first
DrawImagePlaneLoop:
        push    di              ;image is drawn at the same offset in
                                ; each plane
        push    ax              ;preserve plane select
        mov     al,MAP_MASK     ;Map Mask index
        out     dx,al           ;point SC Index to the Map Mask register
        pop     ax              ;get back plane select
        inc     dx              ;point to SC index register
        out     dx,al           ;set up the Map Mask to allow writes to
                                ; the plane of interest
        dec     dx              ;point back to SC Data register
        mov     bx,IMAGE_HEIGHT ;# of scan lines in image
DrawImageLoop:
        mov     cx,IMAGE_WIDTH  ;# of bytes across image
        rep     movsb
        add     di,SCREEN_WIDTH-IMAGE_WIDTH
```


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```
                                ;point to next scan line of image
        dec     bx              ;any more scan lines?
        jnz     DrawImageLoop
        pop     di              ;get back image start offset in VGA memory
        shl     al,1            ;Map Mask setting for next plane
        cmp     al,10h          ;have we done all four planes?
        jnz     DrawImagePlaneLoop
        ret
DrawImage       endp
;
; Copies the image from its current location in VGA memory into the
; buffer at DS:DI.
;
GetImage        proc    near
        mov     si,di   ;move destination offset into SI
        call    GetImageOffset  ;DI is offset of image in VGA memory
        xchg    si,di   ;SI is offset of image, DI is destination offset
        push    ds
        pop     es      ;ES:DI is destination
        mov     ax,VGA_SEGMENT
        mov     ds,ax   ;DS:SI is source
;
        mov     dx,GC_INDEX
        sub     al,al           ;do plane 0 first
GetImagePlaneLoop:
        push    si              ;image comes from same offset in each plane
        push    ax              ;preserve plane select
        mov     al,READ_MAP     ;Read Map index
        out     dx,al           ;point GC Index to Read Map register
        pop     ax              ;get back plane select
        inc     dx              ;point to GC Index register
        out     dx,al           ;set up the Read Map to select reads from
                                ; the plane of interest
        dec     dx              ;point back to GC data register
        mov     bx,IMAGE_HEIGHT ;# of scan lines in image
GetImageLoop:
        mov     cx,IMAGE_WIDTH  ;# of bytes across image
        rep     movsb
        add     si,SCREEN_WIDTH-IMAGE_WIDTH
                                ;point to next scan line of image
        dec     bx              ;any more scan lines?
        jnz     GetImageLoop
        pop     si              ;get back image start offset
        inc     al              ;Read Map setting for next plane
        cmp     al,4            ;have we done all four planes?
        jnz     GetImagePlaneLoop
        push    es
        pop     ds              ;restore original DS
        ret
GetImage        endp
;
; Erases the image at its current location.
;
EraseImage      proc    near
        mov     dx,SC_INDEX
        mov     al,MAP_MASK
        out     dx,al   ;point SC Index to the Map Mask register
        inc     dx      ;point to SC Data register
        mov     al,0fh
        out     dx,al   ;set up the Map Mask to allow writes to go to
                        ; all 4 planes
        mov     ax,VGA_SEGMENT
        mov     es,ax
        call    GetImageOffset  ;ES:DI points to the start address
                                ; of the image
        sub     al,al           ;erase with zeros
        mov     bx,IMAGE_HEIGHT ;# of scan lines in image
EraseImageLoop:
        mov     cx,IMAGE_WIDTH  ;# of bytes across image
        rep     stosb
        add     di,SCREEN_WIDTH-IMAGE_WIDTH
                                ;point to next scan line of image
        dec     bx              ;any more scan lines?
        jnz     EraseImageLoop
        ret
EraseImage      endp
;
; Returns the current offset of the image in the VGA segment in DI.
```

4

```
;
GetImageOffset  proc    near
        mov     ax,SCREEN_WIDTH
        mul     [ImageY]
        add     ax,[ImageX]
        mov     di,ax
        ret
GetImageOffset  endp
code    ends
        end     Start

; *** Listing 2 ***
;
; Program to illustrate use of read mode 1 (color compare mode)
; to detect collisions in display memory. Draws a yellow line on a
; blue background, then draws a perpendicular green line until the
; yellow line is reached.
;
; By Michael Abrash 4/2/88
;
stack   segment word stack 'STACK'
        db      512 dup (?)
stack   ends
;
VGA_SEGMENT     EQU     0a000h
SCREEN_WIDTH    EQU     80      ;in bytes
GC_INDEX        EQU     3ceh    ;Graphics Controller Index register
SET_RESET       EQU     0       ;Set/Reset register index in GC
ENABLE_SET_RESET EQU    1       ;Enable Set/Reset register index in GC
COLOR_COMPARE   EQU     2       ;Color Compare register index in GC
GRAPHICS_MODE   EQU     5       ;Graphics Mode register index in GC
BIT_MASK        EQU     8       ;Bit Mask register index in GC
;
code    segment word 'CODE'
        assume  cs:code
Start   proc    near
        cld
;
; Select graphics mode 10h.
;
        mov     ax,10h
        int     10h
;
; Fill the screen with blue.
;
        mov     al,1            ;blue is color 1
        call    SelectSetResetColor ;set to draw in blue
        mov     ax,VGA_SEGMENT
        mov     es,ax
        sub     di,di
        mov     cx,7000h
        rep     stosb           ;the value written actually doesn't
                                ; matter, since set/reset is providing
                                ; the data written to display memory
;
; Draw a vertical yellow line.
;
        mov     al,14           ;yellow is color 14
        call    SelectSetResetColor ;set to draw in yellow
        mov     dx,GC_INDEX
        mov     al,BIT_MASK
        out     dx,al           ;point GC Index to Bit Mask
        inc     dx              ;point to GC Data
        mov     al,10h
        out     dx,al           ;set Bit Mask to 10h
        mov     di,40           ;start in the middle of the top line
        mov     cx,350          ;do full height of screen
VLineLoop:
        mov     al,es:[di]      ;load the latches
        stosb                   ;write next pixel of yellow line (set/reset
                                ; provides the data written to display
                                ; memory, and AL is actually ignored)
        add     di,SCREEN_WIDTH-1 ;point to the next scan line
        loop    VLineLoop
;
; Select write mode 0 and read mode 1.
;
        mov     dx,GC_INDEX
```


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```
        mov     al,GRAPHICS_MODE
        out     dx,al           ;point GC Index to Graphics Mode register
        inc     dx              ;point to GC Data
        mov     al,00001000b    ;bit 3=1 is read mode 1, bits 1 & 0=00
                                ; is write mode 0
        out     dx,al           ;set Graphics Mode to read mode 1,
                                ; write mode 0
;
; Draw a horizontal green line, one pixel at a time, from left
; to right until color compare reports a yellow pixel is encountered.
;
; Draw in green.
;
        mov     al,2            ;green is color 2
        call    SelectSetResetColor ;set to draw in green
;
; Set color compare to look for yellow.
;
        mov     dx,GC_INDEX
        mov     al,COLOR_COMPARE
        out     dx,al           ;point GC Index to Color Compare register
        inc     dx              ;point to GC Data
        mov     al,14           ;we're looking for yellow, color 14
        out     dx,al           ;set color compare to look for yellow
        dec     dx              ;point to GC Index
;
; Set up for quick access to Bit Mask register.
;
        mov     al,BIT_MASK
        out     dx,al           ;point GC Index to Bit Mask register
        inc     dx              ;point to GC Data
;
; Set initial pixel mask and display memory offset.
;
        mov     al,80h          ;initial pixel mask
        mov     di,100*SCREEN_WIDTH
                                ;start at left edge of scan line 100
HLineLoop:
        mov     ah,es:[di]      ;do a read mode 1 (color compare) read.
                                ; This also loads the latches.
        and     ah,al           ;is the pixel of current interest yellow?
        jnz     WaitKeyAndDone  ;yes-we've reached the yellow line, so we're
                                ; done
        out     dx,al           ;set the Bit Mask register so that we
                                ; modify only the pixel of interest
        mov     es:[di],al      ;draw the pixel. The value written is
                                ; irrelevant, since set/reset is providing
                                ; the data written to display memory
        ror     al,1            ;shift pixel mask to the next pixel
        adc     di,0            ;advance the display memory offset if
                                ; the pixel mask wrapped
        jmp     HLineLoop
;
; Wait for a key to be pressed to end, then return to text mode and
; return to DOS.
;
WaitKeyAndDone:
WaitKeyLoop:
        mov     ah,1
        int     16h
        jz      WaitKeyLoop
        sub     ah,ah
        int     16h     ;clear the key
        mov     ax,3
        int     10h     ;return to text mode
        mov     ah,4ch
        int     21h     ;done
Start   endp
;
; Enables set/reset for all planes, and sets the set/reset color
; to AL.
;
SelectSetResetColor     proc    near
        mov     dx,GC_INDEX
        push    ax              ;preserve color
        mov     al,SET_RESET
        out     dx,al           ;point GC Index to Set/Reset register
        inc     dx              ;point to GC Data
```

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```
        pop     ax              ;get back color
        out     dx,al           ;set Set/Reset register to selected color
        dec     dx              ;point to GC Index
        mov     al,ENABLE_SET_RESET
        out     dx,al           ;point GC Index to Enable Set/Reset register
        inc     dx              ;point to GC Data
        mov     al,0fh
        out     dx,al           ;enable set/reset for all planes
        ret
SelectSetResetColor     endp
code    ends
        end     Start

; *** Listing 3 ***
;
; Program that draws a diagonal line to illustrate the use of a
; Color Don't Care register setting of 0FFh to support fast
; read-modify-write operations to VGA memory in write mode 3 by
; drawing a diagonal line.
;
; Note: Works on VGAs only.
;
; By Michael Abrash 4/2/88
;
stack   segment word stack 'STACK'
        db      512 dup (?)
stack   ends
;
VGA_SEGMENT     EQU     0a000h
SCREEN_WIDTH    EQU     80      ;in bytes
GC_INDEX        EQU     3ceh    ;Graphics Controller Index register
SET_RESET       EQU     0       ;Set/Reset register index in GC
ENABLE_SET_RESET EQU    1       ;Enable Set/Reset register index in GC
GRAPHICS_MODE   EQU     5       ;Graphics Mode register index in GC
COLOR_DONT_CARE EQU     7       ;Color Don't Care register index in GC
;
code    segment word 'CODE'
        assume  cs:code
Start   proc    near
;
; Select graphics mode 12h.
;
        mov     ax,12h
        int     10h
;
; Select write mode 3 and read mode 1.
;
        mov     dx,GC_INDEX
        mov     al,GRAPHICS_MODE
        out     dx,al
        inc     dx
        in      al,dx           ;VGA registers are readable, bless them!
        or      al,00001011b    ;bit 3=1 selects read mode 1, and
                                ; bits 1 & 0=11 selects write mode 3
        jmp     $+2             ;delay between IN and OUT to same port
        out     dx,al
        dec     dx
;
; Set up set/reset to always draw in white.
;
        mov     al,SET_RESET
        out     dx,al
        inc     dx
        mov     al,0fh
        out     dx,al
        dec     dx
        mov     al,ENABLE_SET_RESET
        out     dx,al
        inc     dx
        mov     al,0fh
        out     dx,al
        dec     dx
;
; Set Color Don't Care to 0, so reads of VGA memory always return 0FFh.
;
        mov     al,COLOR_DONT_CARE
        out     dx,al
        inc     dx
```


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Abrash Code, Continued

```
        sub     al,al
        out     dx,al
;
; Set up the initial memory pointer and pixel mask.
;
        mov     ax,VGA_SEGMENT
        mov     ds,ax
        sub     bx,bx
        mov     al,80h
;
; Draw 400 points on a diagonal line sloping down and to the right.
;
        mov     cx,400
DrawDiagonalLoop:
        and     [bx],al ;reads display memory, loading the latches,
                        ; then writes AL to the VGA. AL becomes the
                        ; bit mask, and set/reset provides the
                        ; actual data written
        add     bx,SCREEN_WIDTH
                        ; point to the next scan line
        ror     al,1    ;move the pixel mask one pixel to the right
        adc     bx,0    ;advance to the next byte if the pixel mask wrapped
        loop    DrawDiagonalLoop
;
; Wait for a key to be pressed to end, then return to text mode and
; return to DOS.
;
WaitKeyLoop:
        mov     ah,1
        int     16h
        jz      WaitKeyLoop
        sub     ah,ah
        int     16h     ;clear the key
        mov     ax,3
        int     10h     ;return to text mode
        mov     ah,4ch
        int     21h     ;done
Start   endp
code    ends
        end     Start

; *** Listing 4 ***
;
; Sample code to illustrate various approaches to generating local
; symbols within REPT loops that don't seem to work with MASM 5.0.
;
        dosseg
        .model  small
        .code

macl    macro
        rept    10
        local   testlabel
        jmp     testlabel
testlabel:
        endm
        endm

mac2    macro
        local   testlabel
        rept    10
        jmp     testlabel
testlabel:
        endm
        endm

start:
        macl

        mac2

        rept    10
        local   testlabel
        jmp     testlabel
testlabel:
        endm

        end     start
```


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X Window— A View from DOS

by
M. Steven Baker

Please Pass the Windex

This is the first of a series in which I'd like to focus on technical aspects of various windowing and graphics systems from a DOS perspective. I've started with the acronym X because it has the shortest name. Actually, my hidden motive is that DOS programmers hear a lot about X Windows but rarely get a chance to see the system. Also, the X Windows system is a valuable educational vehicle for studying windowing and graphics because (1) it is fast becoming an accepted standard on workstations (which implies a modicum of success), and (2) although copyrighted, X was developed by a consortium from university and industry and is available in the public domain with a large quantity of source code.

Xtra! Xtra! Read All About It

The X Windows System (or simply X) was developed at MIT over the last several years with considerable support from industry. The primary industry supporter (with both funds and staff) has been Digital Equipment (DEC) although a number of other firms have contributed. While IBM was funding research at Carnegie Mellon (the Andrew windowing system and the MACH operating system) and supplying students with IBM RTs, DEC was busy supporting work at MIT on X and providing VAX workstations to MIT students and staff. In January 1987, eleven large computer firms including DEC, HP, Tektronix, Apollo, Data General, Sony, Adobe, and others joined with MIT in adopting X as an industry standard for graphical computing in networked environments. Conspicuously absent at the onset were Sun and IBM, who have since joined the fold. Standards are affected by politics, and the decisions to support X were likely influenced by political as much as technical motives. Sun had been very successful with its Network File System (NFS), so much so that DEC, workstation vendors, and most recently IBM have had to license this technology from Sun. If some capable alternative hadn't been developed by DEC, IBM, and the other major players, they'd have been faced with licensing Sun's windowing technology next.

X provides* hooks *(a mechanism) rather than* religion *(a policy) for interface design.

The development of X began at MIT in 1984 under the auspices of Project Athena. Project Athena and the MIT Laboratory for Computer Science all of a sudden had dozens—soon to be thousands—of workstations with bitmap displays and needed a window system to make this new computer hardware useful. Although they started with VAX hardware, they expected equal numbers of IBM workstations. Portability was thus one of the early primary goals. Although initially based on Berkeley Unix, X was conceived from the outset as a network protocol that should not depend on aspects of the operating system. The actual name X derives from a Stanford precursor called the W Windows system.

X Marks the Spot

Among the many concepts embodied in the design of X, the most important specifications set forth by the developers were the following:

- ease of implementation on a variety of displays
- device independence for application programs (that is, you shouldn't have to rewrite or recompile your application to support different display hardware)
- network transparency (an application should be able to run on one machine and be displayed on another machine)
- support for many different application and window management interfaces (X does not require a particular user interface design and should be able to support any such design)
- support for concurrent display of multiple applications
- support for overlapping windows, including sending output to partially obscured windows
- support for a hierarchy of resizable windows and for the use of several windows by an application
- high-performance, high-quality support for text, 2D synthetic graphics, and imaging (doesn't everybody want this?)
- extensibility (an extension mechanism should allow additions to the core system)

One of the more interesting concepts for PC programmers is that the windowing system should not dictate the "user interface." The X developers conceded from the start that no single user interface design is "best." Users may have very different preferences for interfaces. For example, experts and novices

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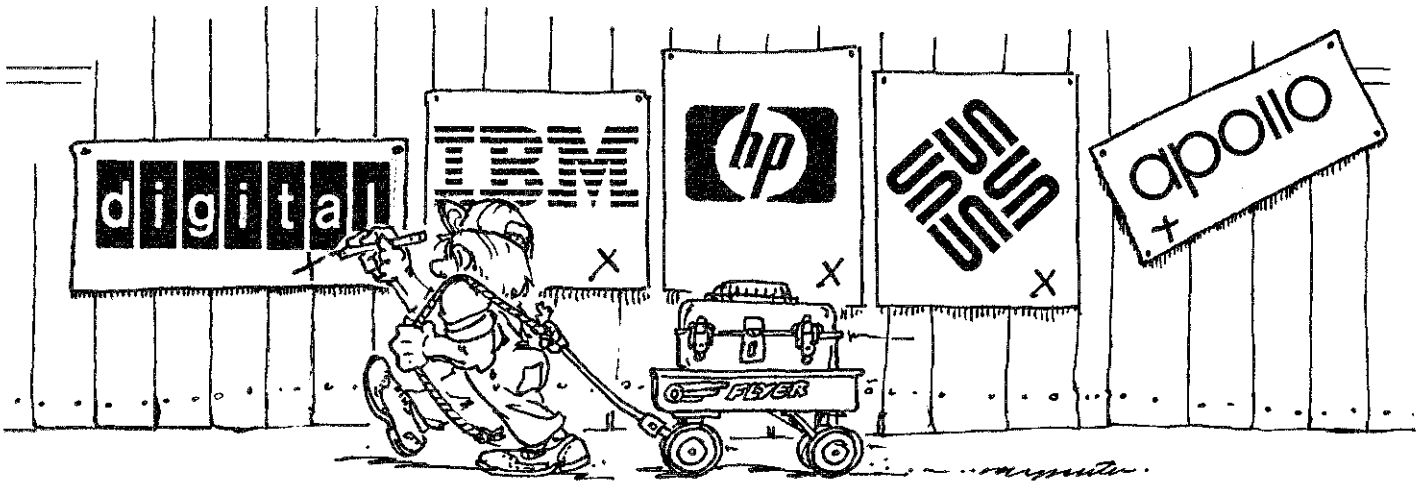

may make very different demands on a system. And the special requirements of applications themselves may dictate different kinds of interfaces. Rather than require a specific user interface, X allows a wide range of interfaces to be constructed. X provides *hooks* (a mechanism) rather than *religion* (a policy) for interface design. The base system contains primitives from which menus and other objects may be constructed. This is certainly worlds apart from the programmer's model of Microsoft Windows.

The X System Model

X is based on a client-server model, which may be confusing jargon to a PC programmer. The X client-server relationship means that for every physical display (screen), there is a controlling server program. A client program and a server communicate via a reliable byte stream (8-bit) protocol. The client and server programs are separate and do not have to reside in the same machine. For example, the server might run on your PC and the actual application program might be running on a VAX, a Cray, or another PC. The server shouldn't care. The X protocol merely requires a reliable byte stream for communication. This could be based on local interprocess communication (server and client on the same machine) or a network connection using anything from an RS-232 line to an ethernet or token-ring network board. X is most commonly implemented on Unix machines over network connections using TCP/IP (a Department of Defense network protocol—see *PJ*, Miscellaneous, 6.2). Although a simple serial line could be used, decent response and performance mandate 50,000+ baud or more because of the quantity of client-server communication. Note that the X client-server model is just the opposite of PC file servers, where the file server is the big fast machine and the lowly PC is the client.

The X server is the workhorse of the window system. The server provides all the fundamental graphic resources and mechanisms for the system. The X server contains almost all device specific code so that all these hardware dependencies are on only one end of a network connection. The X Server directly controls the screen (display), keyboard, and mouse hardware along with other X devices such as bar code readers. Any new video or input hardware needs only the development of a new server implementation to be fully functional. The X server code itself is designed as a layer of device independent code overlying the hardware dependent device code.

I was fascinated by the possibilities for X in the evolving PC world. If I could port an X server to the PC, I could

Porting X—Tribulations of a Part-timer

I started corresponding with Project Athena staff regarding X over a year ago. At the time, the current X Windows system was Version 10 Release 4. X Version 11 was released in September of 1987, and incorporated very substantial changes from Version 10. Where Version 10R4 was a relatively austere system, Version 11 was aimed at correcting all of the deficiencies in the earlier prototypes but with increased complexity and size. While an X Version 10R4 server might take 140K, the X11 servers had grown to a characteristic 400K. Apple dropped its contract for an A/UX port of X11 after the consultant who had done a number of X10 ports had to revise his contract costs after working a few days with the new X11 distribution.

The first release of Version 11 also came with quantities of bugs (over 100 patch fix files had been issued by early 1988). I received my first distribution tape containing X11 in November 1987, free, thanks to the GNU project (Richard Stallman and Co.). Please remember that X was developed almost exclusively on machines running Unix, so the distribution came as a Unix tar tape (that is, one big file containing all the directories and files). On the GNU tape, the large X11 tar file had been compressed using the Unix compress (public domain) utility program (similar in concept to the ARC program used in the PC world).

The first step was to read the tape on the friendly minicomputer and kermit the compressed tar file (7 megabytes) to the PC—no problem, except for transfer time at 19,200 baud. The next step was to uncompress the tar file. After some searching, I located a copy of the source code to compress via my local university connections and Usenet. To the contrary of what you may read, porting programs from the 32-bit Unix world to the 16-bit DOS world is not without its frustrations. The Unix compress utility uses a 16-bit LZW encoding (ARC uses at most 12-bits) necessitating 256K (64K entries by 4 bytes) for the main array and the use of longs instead of ints. After several tries, I finally got an executable DOS version of compress, albeit agonizingly slow (several hours to uncompress a 7 megabyte file to 20 megabytes of source code)—halfway to the PC. The next step was to find a public domain version of the Unix tar program (through university connections again). After a few trials and more tribulation, I had a DOS version of tar functioning. Aside from truncated Unix file names, I finally got the X source code into the PC. Now the real work begins.—*MSB* ♦

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develop and run client programs on the Definicon 68020 coprocessor board or the A. I. Architects 80386 Hummingboard (see *PJ* 6.1), communicating with a DOS X server via interprocess communication. On a 386 machine using one of the 386 DOS extenders, I could run the server as a DOS TSR in the lower 640K communicating with a client developed and running in the protected mode in extended memory. Using one of the newer high-end graphics boards based on the Texas Instruments 34010 processors, I could develop an X server that ran mostly on the display card and communicated with client programs on the PC. Most of these new TI 34010 based cards have 256–512K of program memory on board in which to download programs for emulation. Finally, a PC based X server could communicate with other machines using a network connection—although normally I don't have a Sun or VAX sitting conveniently down the hall.

Sample X Protocol Requests

CreateWindow	Creates an unmapped window (not viewable and assigns an identifier to it
ChangeWindowAttributes	Changes attributes of a window
GetWindowAttributes	Returns current attributes of the window
DestroyWindow	Window and all inferiors are destroyed
DestroySubwindows	Performs a DestroyWindow on all children
ChangeSaveSet	Adds or removes specified window from client's "save-set"
ReparentWindow	Changes the parent of a window and inserted as child of the specified parent
MapWindow	Window is mapped (made viewable)
MapSubwindows	Performs a MapWindow on all unmapped children
UnmapWindow	Window is unmapped (made not viewable)
UnmapSubwindows	Performs an UnmapWindow on all mapped children
ConfigureWindow	Changes the configuration of the window
CirculateWindow	Raises or lowers a mapped child in the stack of windows
QueryTree	Returns the root, parent, and children of the window
GetGeometry	Returns the root and current geometry of a drawable
InternAtom	Returns the atom (resource-ID) for a given name and creates if it doesn't exist
GetAtomName	Returns the name for a given atom
ChangeProperty	Alters the property of an atom for a specified window
DeleteProperty	Deletes the property of an atom for the specified window
GetProperty	Return the property for an atom in a window
ListProperties	Returns the atoms of properties currently defined on the window
SendEvent	Sends event to a window or possibly on to all child windows
GrabPointer	Actively grabs control of the pointer device for a window
UngrabPointer	Releases the pointer
GrabButton	Establishes a passive grab of a button/key for a window
UngrabButton	Releases the passive button/key combination
GrabKeyboard	Actively grabs control of the keyboard for a window
UngrabKeyboard	Releases the keyboard
GrabKey	Establishes a passive grab of specific key for a window
UngrabKey	Releases the key combination
QueryPointer	Returns the relative pointer coordinates to root window
GetMotionEvents	Returns all events in motion history buffer that fall between a start and stop time
TranslateCoordinates	Translates coordinates between a source and destination window
WarpPointer	Moves the pointer relative to current position
QueryKeymap	Returns a bit vector for the logical state of the keyboard indicating which keys are pressed

The Hardware It eXpects

X makes several general assumptions about the underlying hardware. It expects that some form of fast interprocess communication mechanism between the server and the client will be available. X Windows is based on modeling the display as a two-dimensional array of pixels which may have some depth (for representing color or shades of gray). Both monochrome and color displays are supported. The number of bits per pixel, and how the value translates into a color, depends on hardware. X has a most elegant model for keyboard and mouse event input. The keyboard is considered a collection of buttons that sometimes go down and sometimes go up, possibly in combination with other keys. Significance is attached to both key press and release events. A large number of modifier keys are supported along with a variety of key symbols and meanings. The mapping of any keycode is under the control of the X server. A pointing device (usually a mouse) can have buttons up to a maximum of ten although most of the applications provided with the X distribution assume a three-button mouse. X requires support for cursor, text output, and line drawing, which may all be implemented in software. X assumes very little about the underlying display hardware. Because of this design, an X server can be implemented on a simple memory mapped video board (a frame buffer in graphics jargon) such as a Hercules card or on a powerful display card with its own CPU (like the many new PC cards based on TI 34010 graphics coprocessors).

The X Protocol

I can't begin to describe the complete protocol specification here, but I'll try to give you a taste of it and refer you to the actual documentation. The first issue that the X protocol attacks is the byte ordering problem. The sending of 16- or 32-bit quantities over an 8-bit byte stream for various machines requires that some decision on byte ordering be made (the big-endian, little-endian problem). The X server is designed to accept both big-endian and little-endian connections. Client

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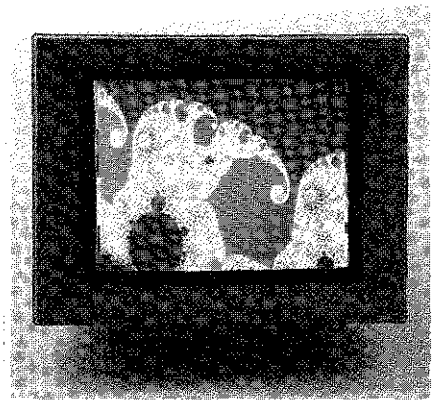

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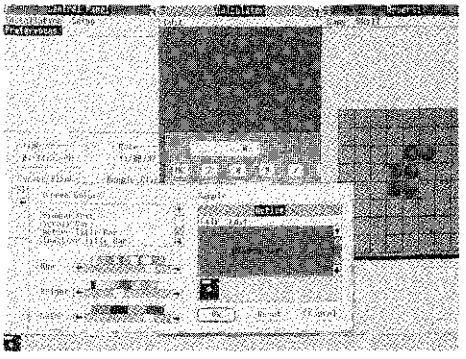

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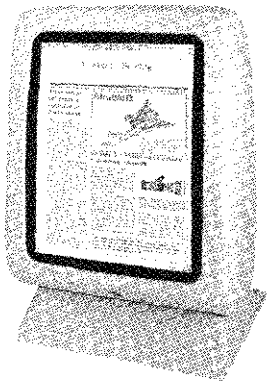

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programs always send and receive in their native byte order (except that raw bitmaps and image data are sent to the server in its preferred format). The server is responsible for all byte swapping. The X protocol also takes care of word alignment problems on various architectures. The protocol always consists of blocks that are multiples of 32 bits, and each 16-bit and 32-bit quantity within a block is aligned on 16-bit and 32-bit boundaries, respectively. A protocol request from a client is simply a data packet containing an opcode, some fixed length parameters, and a variable amount of data.

The X protocol supports four formats: (1) request, (2) reply, (3) error, and (4) event. Every request format contains an 8-bit "major" opcode and a 16-bit length field expressed in units of 32-bits (4 bytes) followed by additional bytes of data. The length field defines the total request length, including the header. The actual maximum block size to use for communication is determined by the server at connection setup and can range from a minimum of 16K to a 256K maximum. The base X protocol uses opcodes through 127, and opcodes 128 through 255 are reserved for extensions. Every request on a given connection is implicitly assigned a sequence number starting with 1 that is used for replies, errors, and events. The client sends request formats to the server. The side bar that accompanies this article provides a sample list of some requests that are supported.

Reply formats (from the server) are similar, each containing a length field expressed in 4 byte units along with any data bytes. Every reply also contains the least significant 16 bits of the sequence number of the corresponding request. Reply formats are a minimum of 32 bytes long.

Error formats (from the server) are 32 bytes long. Every error packet includes an 8-bit error code, where again error codes 128 to 255 are reserved for extensions. Every error packet also includes the opcode of the failed request and the least significant 16 bits of the sequence number of the request.

Event formats (keyboard or mouse input sent from the server to the client) are 32 bytes long. Every event contains an 8-bit type code where event codes 64 through 127 are reserved for extensions. An event packet also contains the least significant 16 bits of the sequence number of the last request issued by the client. An event packet also contains a millisecond timestamp field set by the server.

The X graphics model is completely pixel or raster based. The core protocol supports displays with pixels up to 32 bits in depth. This should satisfy your urge for a few more colors on your CGA board. Request opcodes support graphics primitives such as point, line, polyline, and polygon fills along with much higher level abstract calls. Request opcodes also support resource IDs for types WINDOW, PIXMAP (an image bitmap of off-screen memory), CURSOR (which may be of any size or shape), FONT (supports both fixed width and proportional fonts stored as bitmaps), GCONTEXT (graphics context of defaults for various values), and COLORMAP. Clients request creation of a resource by supplying various parameters (for example the name of a font). The server allocates the resource and returns a resource-ID (often called a handle in the DOS world) passed as a unique 32-bit value. Any client that knows the identifier of a resource can use and manipulate the resource at will—even if the resource was created by another client. This capability allows window managers to be written independent of other applications. For example, to display some text in a window, the parameters passed in a request packet would include the drawing color and the identifiers for the window and the font, along with the actual string of characters.

X supports an arbitrary branching hierarchy of rectangular windows. At the top is the root window, which covers the entire screen. Windows are visually clipped by their parent windows. The coordinate system has an origin (0,0) in the upper left window corner with *x* axis horizontal and *y* axis vertical. This corresponds directly with most hardware. A window can optionally have a border. Windows can be created, destroyed, mapped and unmapped, moved and resized, and raised to the top or lowered to the bottom of a stack. X supports

Figure 1: Connection Setup

Client sends the following:	
byte-order byte	(either "B" or "l")
protocol-major-version	unsigned 16-bit
protocol-minor-version	unsigned 16-bit
authorization-protocol-name	string
authorization-protocol-date	string
Received by the Client	
success:	byte (true or false)
protocol-major-version:	unsigned 16-bit
protocol-minor-version:	unsigned 16-bit
length:	unsigned 16-bit
Additional data received if authorization fails:	
reason:	string
Additional data received if successful:	
vendor:	string
release-number:	unsigned 32-bit
resource-id-base and mask:	unsigned 32-bit
image-byte-order:	LSBfirst or MSBfirst
bitmap-scanline-unit:	8, 16, or 32
bitmap-scanline-pad:	8, 16, or 32
bitmap-bit-order:	Least or Most Significant
pixmap-formats:	list of supported FORMATs
roots:	list of possible SCREENs
motion-buffer-size:	unsigned 32-bit (for mouse events)
maximum-request-length:	unsigned 16-bit (packet max)
min-keycode, max-keycode:	for the keyboard

Note: SCREENs and FORMATs are further data structures. For example, a SCREEN data structure contains information about the various display screens supported by the X server. This includes screen width and height in pixels and millimeters, the allowed pixel depths, default colormap data, the value to be used for a white-pixel and a black- pixel, installed pixel maps, whether the server supports off screen memory to save over-written screen real estate, etc.

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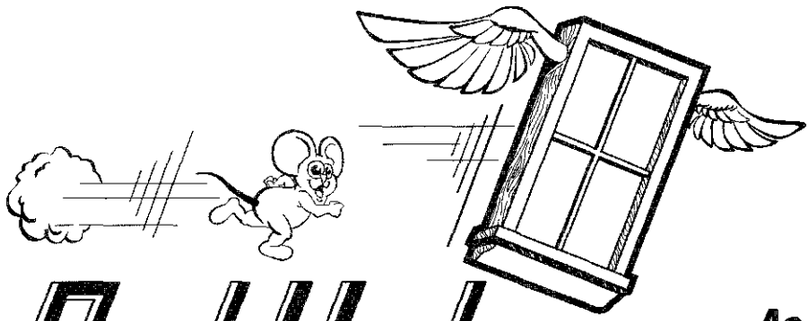

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several window types: (1) opaque (the most common), (2) transparent (always invisible but provides clipping), and (3) input-only.

Resources have associated with them interesting properties such as bit-gravity (if a window is resized, in which direction this drawable should be moved), window-gravity, copy-from-parent (whether class, pixel depth, etc., should be copied from the parent), along with defaults for borders, background pixmaps, cursors, fonts, colormaps, etc. Bit image data may be sent as either single bit-planes or pixel-depths.

For remote clients, the X protocol can be built on top of any reliable byte stream. A connection setup process begins with a client program's sending an initial byte to identify the byte order to be used. An ascii "B" means that values will be transmitted most significant byte first while an ascii "l" means least significant byte first. With the exception of image data, all 16-bit and 32-bit quantities sent by the client and those returned by the server must use this byte order. Following the byte-order byte, the client sends a block of information identifying the protocol version and revision numbers and authorization information if security is implemented. The server sends back a Boolean success or failure block with similar information. If the connection was successful, the server also appends to this block a large list of detailed information about the server. This process is conceptually illustrated in Figure 1.

The X Distribution

The first release of X11 in September 1987, contained over 20 megabytes of source code. X Version 11 Release 2 was made available on March 1988. This second release of Version 11 comes with over 60 megabytes of source, mostly in C. Release 2 cleaned up a lot of bugs from the earlier release and is much more robust. No changes have been made to the X protocol and other basic components. The current release (X11 Release 2) is divided into two distributions—supported (the basic X stuff) and contributed (user contributed code). Each distribution contains two Unix **tar** files—one for source code and one for printable versions of the documentation, mostly in Postscript (PS) format ready to be dumped to a laser printer. If downloaded directly over Arpanet from MIT, the four **tar** files are compressed and split into parts of 512,000 bytes each. The following table summarizes the **tar** file sizes:

Distribution	Contents	Megabytes	Needed
supported	source code	20	required
supported	documentation (PS)	7	optional
contributed	source code	22	recommended
contributed	documentation (PS)	10	optional

The X distribution has grown in size not because of changes to the underlying protocol, but because more sample servers are included, more X toolkits are incorporated, and more user contributed programs are bundled. The distribution depends on extensive makefiles and a few utilities to be constructed for your environment. X server code is included for the machines and displays from DEC, Sun, Apollo, HP, the IBM RT, and sample monochrome and color servers. The new IBM servers include source code support for the EGA and VGA, along with the older display hardware available on the RT (IBM also included a binary object module supporting the 8514 display). The default distribution will build easily only on a Unix system (preferably Berkeley 4.2 or better) for the supported hardware. A C compiler that has 32-bit integers will also make the porting job easier. While X Version 10R4 was a more spartan system, Version 11 was intended to correct all of the deficiencies in the earlier prototypes but added complexity. While an X version 10R4 server might take 140K, the X11 servers have grown to a typical 400K.

XLIB, Toolkits, and Clients

The X distribution also includes an XLIB library in C, encapsulating the basic X protocol operations as several hundred C function calls. A draft Common Lisp interface library is also included. These libraries should be considered similar to the low level I/O calls available for Unix. The distribution also includes four higher level toolkits designed to make developing applications easier (these may be thought of as the STDIO package under Unix). The four toolkits provided are described below:

X Toolkit Intrinsics: provides a collection of resource, event, and object managers written in C that may be used to build user interface objects called "widgets." A sample set of widgets is provided.

Xrlib: provides a collection of user interface utilities and higher-level objects written by Hewlett-Packard. Future releases are to be based on the X Toolkit Intrinsics.

Andrew Toolkit: developed by IBM and Carnegie Mellon for the Andrew System at CMU, this package provides a collection of integrated, high-level objects and applications.

Interviews: developed at Stanford, this package provides tools for building user interface objects in the C++ programming language.

The distribution also contains a large number of client programs. These range from the simpler bouncing ball demos, clocks, and calculator programs to terminal emulators, mail programs, editors, and a window manager. The earlier release contained several window managers. Again, one of the strengths of X is that it doesn't dictate a window manager: One could write a window manager that looked like the MAC, Microsoft Windows, or the new Open Look windowing manager specification under joint development by AT&T and Sun for Unix.

Last eXit

I've tried to provide a brief introduction to X and convey some of its flavor. The size and breadth of X is representative of the new, more powerful windowing and graphics systems—that is, large amounts of code initially containing hundreds of bugs. In the case of X, we are fortunate to have the source code readily available for review and study. The X development is now managed by the X Windows consortium, a group of industry organizations and MIT.

In closing I've included the ubiquitous Hello World program, this version written by David Rosenthal of Sun Microsystems using the X toolkit. ♦

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Specification

The "Hello World" problem should be slightly restated for the world of window systems. The program needs to

- Create a window of an appropriate size and position it on the screen if required.
- Paint the string "Hello World" in a suitable font, centered in the window.
- Paint the string in a color that will contrast with the window background—it is not acceptable to paint an invisible string.
- Deal with its window being exposed—repainting the window if required.
- Deal with its window being resized—re-centering the text.
- Deal with its window being closed into an icon and re-opened, providing suitable identification of the icon.

Note that this specification is much more complex than the canonical "Hello World" program, so it's likely that the resulting programs will be significantly more complex.♦

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```
#include <stdio.h>
#include <X11/Xlib.h>
#include <X11/Intrinsic.h>
#include <X11/Atoms.h>
#include <X11/Label.h>

#define STRING  "Hello,  World"

Arg wargs[] = {
XtNlabel,    (XtArgVal) STRING,
};

main(argc, argv)
int argc;
char **argv;
{
    Widget      toplevel, label;

/*
* Create the Widget that represents the window.
* See Section 14 of the Toolkit manual.
*/
    toplevel = XtInitialize(argv[0], "XLabel", NULL, 0, &argc, argv);

/*
* Create a Widget to display the string,  using wargs to set
* the string as its value.  See Section 9.1.
*/
    label = XtCreateWidget(argv[0], labelWidgetClass,toplevel, wargs,
XtNumber(wargs));

/*
* Tell the toplevel widget to display the label.  See Section 13.5.2.
*/
    XtManageChild(label);

/*
* Create the windows,  and set their attributes according
* to the Widget data.  See Section 9.2.
*/
    XtRealizeWidget(toplevel);

/*
* Now process the events.  See Section 16.6.2.
*/
    XtMainLoop();
}
```

The X Windows 11 Release 2 distribution is available for downloading via Arpanet or may be purchased from MIT on two 9-track Unix *tar* tapes at $200 each (one tape for the Core distribution and one for the User Contributed software). Documentation is included when you purchase the magnetic tapes. If you just want more details, printed documentation is also available from MIT in two sets: (1) X Core Distribution (800+ pages) at $30; and (2) X User-Contributed Software (500+ pages) at $20. Tapes or documentation may be ordered prepaid from MIT.

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I'd like to thank several hardware and software vendors for product loans I'm using to port X Windows to the PC:

Texas Instruments (Austin, TX): TMS34010 Development Board, 34010 C compiler, and assembly language tools.
PC Tech (Lake City, MN): TMS34010 Color Graphics Board
Logitech (Fremont, CA): EGA & Mouse (EGA and mouse card with multiscan monitor)♦

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A Digital Clock for Microsoft Windows

by
Michael J. Babcock
William S. Hall

In this article, we show you how to write a simple program in Microsoft Windows. When all's done, you will have a useful utility containing the essential ingredients of every Windows program that can serve as a model for your independent efforts. At the same time you will see a variety of techniques commonly used in Windows—registering a window class, borrowing data from a previous instance, reading the windows initialization file, creating a window and sizing it in a device-independent way, creating a logical font, using the timer, painting the window, and segmenting a program. If you understand these ideas, you will be able to write your own elementary applications and you will have a basis for further study.

This program is written for the Windows 2.0 and Windows/386 environments. Windows 1.0 is already obsolete, and if you are a registered owner of Windows, you should take advantage of the $25 2.0 upgrade offer from Microsoft.

Code for the program is available on the *PJ* bulletin boards and Issue Disk for Volume 6.4. Also included on the BBS's and disk are the small memory model template described at the end of the article and a useful device driver, OX.SYS, which we have found to be immensely valuable in analyzing and debugging Windows programs.

Description of the Program

DC (Digital Clock) shows the system time in a window. If DC is running as an overlapped window, the time in hours, minutes, and seconds is redisplayed about once every second. If the window is iconic, the time in hours and minutes is shown in the icon area, but updates occur only once a minute. What is interesting about the icon display is the need to load and use a small font so that all the information can be seen. As it is difficult to predict the readability of the icon display for a given video adapter, we have given the user the option of selecting the font's parameters using the Windows initialization file **win.ini**. The parameters default to those we have found to be satisfactory for a display comparable to the EGA's.

The **win.ini** entries (which you should make using a text editor such as NOTEPAD, the Windows version of EDLIN) are as follows:

```
[DC]
fontheight=n1
fontwidth=n2
fontweight=n3
```

where n1, n2, and n3 are the height, width, and weight of the font. Experimentation suggests that 8, 6, and 700 are good values for an EGA, VGA, or Olivetti/AT&T 640 x 400 screen whereas 6, 4, and 400 produce good results on the CGA.

The first time DC is run, its window is placed in the lower right corner of the screen. Each subsequent instance appears at a location selected by Windows. If you enter DC.EXE in the **load=** line in **win.ini**, the program will start up as an icon when you execute Windows.

Windows Programming Software

You'll need the Microsoft C compiler, Version 4.0 or greater. As far as we know, no other current C compiler is "Windows aware" although Microsoft has freely distributed the specifications. Certain Windows functions require a special prologue and epilogue, and the Microsoft compiler is able to furnish this code. You must also have the Windows Software Development Kit (SDK), where you will find the libraries, headers, and utilities you need in order to write programs in Windows. Although each package lists for about $500, they are frequently heavily discounted to around $270 each. If you already own earlier versions of either the compiler or SDK, by all means upgrade them.

Windows Programming Hardware

If you have a machine capable of running Windows, you have the basic hardware needed to develop Windows programs. But you may not be very well prepared to debug them. Because Windows owns all the machine's resources, you need to have an auxiliary terminal connected to one of the communications ports. Then you can run SYMDEB (supplied with the SDK) and direct all debugging input and output to the terminal. You can even debug at the source code level if you've set the right switches during compilation and linking; however, you can't see automatic variables unless you understand how the stack is arranged. Despite these and other limitations, SYMDEB can be a useful tool for tracking problems in Windows.

You can use temporary **printf** statements for debugging purposes (even though the output will not show on the display) if you run Windows with output redirected to an appropriate device such as an auxiliary terminal, printer, or file. Standard output will then appear there, and this can be very helpful in analyzing what a Windows call is ac-

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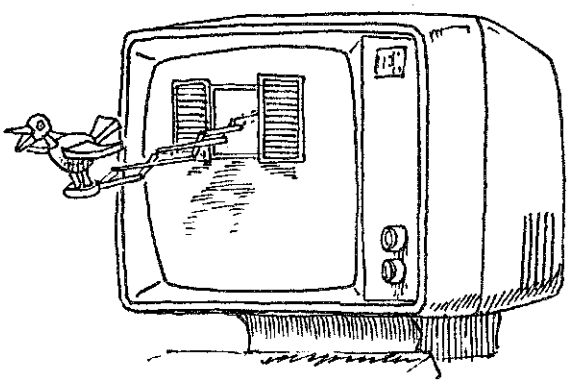

tually doing. But don't leave any permanent **printf**s in your program.

As an alternative to the auxiliary terminal, you may want to run dual monitors using an EGA, CGA, or VGA as the primary video and a monochrome or Hercules board as the secondary display. If you combine this arrangement with the public domain program OX.SYS, you'll have a very useful arrangement. By redirecting Windows to AUX, you can see standard output displayed on the monochrome screen. SYMDEB can be redirected there as well, and you do not lose the use of a communications port.

Windows Program Memory Models

Because Windows is a multitasking environment, several programs may be in CPU memory at the same time. Lacking a real paging system, Windows takes advantage of the segmentation architecture of the Intel processor. Most Windows programs are made up of several segments, each located in its own area of the global heap. These segments can be moved, shared, and even discarded. And although the effects of memory management can generally be ignored by the programmer, there are times when he or she must be aware of the consequences. For example, a long pointer to a segment that can be moved will not be valid indefinitely. And if the program's code is monolithic, Windows can't make efficient use of the limited memory available. Thus, it really is necessary to plan a program's optimal layout.

One of the simplest schemes for taking advantage of Windows memory management is to divide a program into two segments, one of which contains only initialization code. If the initialization segment is so marked, it will be discarded when it is no longer needed and its space will be made available for other programs. Since at least two code segments are required, the so-called medium memory model is implied. In fact, this is the best model for writing Windows programs having only one data segment simply because it makes the mechanics of program segmentation very easy.

It is also possible to have more than one code segment in the small memory model as we have done here, But certain precautions must be observed. For example, calls between different segments must be labeled FAR. You can call a library function only from the _TEXT segment (the default code segment) since all such functions are NEAR. **WinMain**, the entry point for Windows, must be in _TEXT. Finally, unless you say something specific about the segments in the program's definition file, they will be grouped together by the linker anyway. We will explain this in greater detail below.

A window class is basically a data structure containing a collection of attributes common to all windows of that class.

The Make File for DC

Windows programs have so many pieces that you really must use some kind of **make** program. Such a tool is supplied with the Microsoft C compiler. Its syntax is similar to the Unix version's and so will be familiar to many of you. We have tried to keep ours simple, but we have taken advantage of the macro feature in order to help you accommodate a variety of compiler versions and libraries. You can use these macros to tailor the **make** file to your own environment.

Beginning at the top of Listing 1, you will see some compiler macros with the switches needed for making "normal" as well as debugging versions. Although you should review the exact meanings of the switches used with the compiler, here is a summary of the ones we use:

-d	show each pass of the compiler
-c	make an object file only
-AS	compile for the small memory model
-Gw	compile for Windows (PASCAL keyword)
-Zp	pack structures
-Ox	maximum optimization

You can't omit **-Gw** or **-Zp**. In the debug compile macro, the optimization has been removed and an additional switch **-Zd** has been added to place line number information in the object file. By default, stack probes are restored.

Then follow several macros that show you which libraries to use at link time. The macro you should choose depends on your compiler version. We have also assumed that you have *not* elected to make compound libraries if you have either the OS/2 development kit or the 5.0 compiler. If you have built composites, please develop your own library macro; there are too many variations for us to guess your configuration.

If you plan to use floating point numbers, read how to do this in the Windows SDK. You must avoid linking with the emulator library.

After the macro definitions is the command needed to make the resources for the program. Resources are objects such as dialog boxes, fonts, strings, icons, bitmaps, and menus. A source resource .RC file describes these objects in text format using the appropriate syntax. The resource compiler RC then converts this description into a binary

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.RES file. After the executable .EXE file is made, RC is again used to attach the .RES file to the .EXE. DC has only one resource, which is not typical of a Windows program, but we wanted to keep it simple.

Next are the commands to make the .OBJ files from the .C sources. (To make a debugging version, replace the **cp** macro with **cpd**.) You should note the named segments specified by the -NT switch. This information is used by the linker in combination with the .DEF file to separate the code into two segments.

Finally, the Windows executable file is put together using several commands. Note the use of a special linker, LINK4. Windows programs use the same .EXE format as OS/2. Some of the new features provided are dynamic linking (linking to libraries at runtime rather than at link time) and memory management (some aspects of which we have already described).

The **align** command is not critical; it just specifies the separation of segments in the disk file. The default is 512, so the file is a bit smaller if 16 is used. We have also included the line number switch **li** in case you have compiled for debugging. The appropriate library macro, which you should select according to your configuration, follows. Then comes a new element, the definitions file, which we examine next.

After the executable is made, the resources must be attached. Again, the resource compiler is run, this time without the **-r** switch. Then a symbol table file that can be read by SYMDEB is created by the MAPSYM utility.

The Definitions File

Every Windows program requires a .DEF file. Ours (Listing 2) is minimal. The first entry is the name of the program. You *must* be sure that it agrees with the program's .EXE name; otherwise, multiple instances will not be recognized and code segments will not be shared.

The description string is optional, but the stub is rather interesting. This is the MS-DOS program you want to be executed if someone tries to run your program outside Windows. Generally, WINSTUB.EXE, which is supplied on the Windows SDK, is used, but it could just as well be Lotus 123, or perhaps more realistically, a non-Windows version of your program.

Next is a general declaration about the code and data. Since you can have several instances of the same program in memory, data is not shared and thus must have as many realizations as you have instances. Code, however, can be shared, and this is the default. We allow both code and data to be moveable.

We also supply specific information about the two code segments we have created. This information is *absolutely necessary* if you want to have two separate segments during runtime in the *small* memory model. Note that we have marked the initialization segment as discardable.

We have exported the only entry point Windows will have into our program, the window procedure **MainWndProc**. Windows will now be able to locate and call this function whenever it has information for us. Note that *all* functions in a program that Windows may call—dialog box handlers, callback functions, and window procedures—must be exported in the application's .DEF file.

The Resource File

DC's only entry in the resource file (Listing 3) is a string table. Although a Windows program can have strings as part of the source code, it is usual to put them into the resource file. Since the resources are also in segments that are moveable, discardable, and separate from the rest of the code or data, it is advantageous in terms of runtime memory considerations to keep strings here.

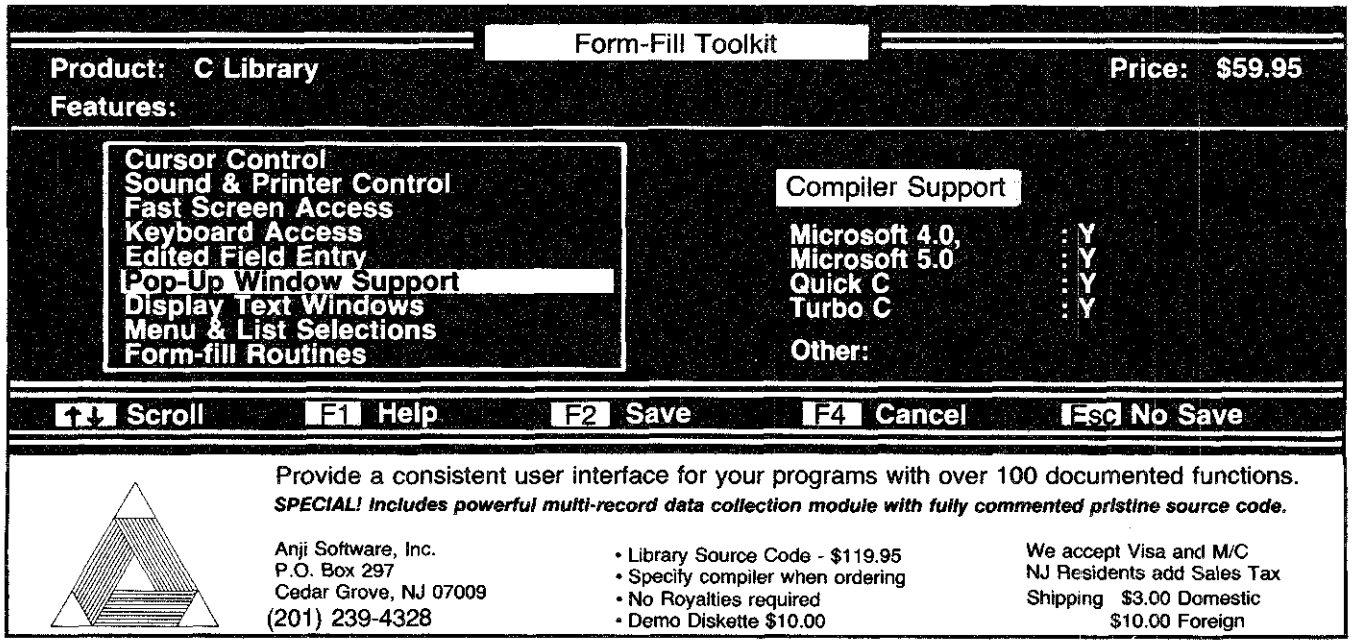
In addition, it's easy to internationalize a program by translating the strings and then replacing the resources with the new ones. It's not necessary to recompile the entire program but only to pass it through the resource compiler.

In our resource file we keep the strings used for the application name, part of the time display, reading **win.ini**, and getting information about the display adapter on which Windows runs.

Associated with each string is a constant defined in the program's include file. When the string is needed, it is loaded by referring to this value.

The Header File

The header file (Listing 4) is quite simple. Here we declare those variables shared by the two code segments, and we define the string manifests. By use of the device at the top of the file, we ensure that the globals are declared only in the file where EXTERN is defined as



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null while in all other files, globals are noted as external.

We also declare the two functions referenced in both modules since their forms differ from the small memory model default's. In particular, the initialization function, which is an inter-segment call, is declared FAR, and the windows procedure, since it is called by Windows, is tagged as FAR and PASCAL. This last keyword means that variables are pushed on the stack from left to right, an order opposite from that of standard C. The prologue/epilogue code is added, and finally, the callee, not the caller, restores the stack. All Windows functions follow this convention, but functions local to a program do not have to be declared PASCAL.

The Initialization Module

Now we can discuss the code. Look at the DCINIT.C module (Listing 5). At the top, note the inclusion of **windows.h**, a file supplied on the Windows SDK. Everything needed by a Windows program—data structures, type definitions, macros, constants, and all Windows function declarations—is defined in **windows.h**. You can find many undocumented features of Windows here. Although **windows.h** is very large, it is possible to substantially reduce compile time by inhibiting certain definitions. The technique is described at the beginning of the file.

Below the include statements and the local function declarations, you will see **InitProgram**, the first function called when DC is invoked. The parameters passed are the same as those given to **WinMain**, the program's entry point. Two of these are instance handles; the first to the current instance, the second to a previous invocation of the program. There is also a long pointer to the command line, but this string is not broken into its fields as is **argv** in C. The parameter **cmdShow** indicates how the window is to be initially displayed—iconic, normal, or maximized (zoomed).

If this is the first invocation of our program, we load those strings used in the time display, register the class of the main window, and create a logical font small enough to be used when writing to the icon. If this is a later instance, we simply borrow these strings from some previous instance. We can also retrieve a handle to the small font. It is not necessary to register the window class again nor to recreate the font.

Next, we create and display a window of the class we have just registered. Then we start the Windows timer, causing a message to be sent to our Windows procedure about once per second. We use this as a signal to read, record, and if necessary, update the time display.

The timer can be used in one of two ways. In this program we simply ask for a WM_TIMER message to be placed in our message queue whenever a timer event occurs. By using different parameters in **SetTimer**, we can request Windows to directly call a procedure of our own, a so-called "callback" function. The callback function must have a specific form, be declared PASCAL, and be exported in the definitions file. In addition, a pointer to the function must be prepared using the Windows function **MakeProcInstance**. Many operations in Windows depend on this callback principle.

If any of these actions fails, FALSE is returned to the caller and the program exits. Now, let's study more closely each routine called by the initialization function.

A window class is basically a data structure containing a collection of attributes common to all windows of that class. Included are the mouse cursor style, menu, class name, background brush, class style, and (most important) the window procedure. To register a class, it is necessary only to fill in the WNDCLASS structure and pass it to Windows. Since Windows copies it, we can destroy the structure after **RegisterWindowClass** returns successfully.

We begin by allocating space in the local heap to hold the WNDCLASS structure. Allocations in the heap can be moved, compacted, or locked in position, and Windows manages this area in somewhat the same way it does global memory. So the first step is to obtain a handle to a memory block with **LocalAlloc**. Then when the handle is to be used, it must be locked in order to retrieve its pointer. Later, when the memory is to be deallocated, it must be unlocked, then freed.

When we use the attribute LPSTR in the **LocalAlloc** call, we ensure that the memory retrieved is set to zero and is fixed. Although the fact isn't documented, the handle returned in this case is the actual pointer, and a call to **Local-**

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Lock isn't really necessary. But we go through the formalities to illustrate proper techniques for working with the heap.

Now we fill in the WNDCLASS structure for the clock program. We use a standard arrow cursor. Since we have no bitmapped icon nor menu, we enter a NULL for each. As the class name should be unique, we use the name of our program. Because we want Windows to maintain the background, we specify a brush (which in this case is white). (If an application wants to paint its own background, a NULL is entered in the WNDCLASS background brush field, but the application must then be prepared to create its own brush and to respond to the WM_ERASEBKGND message from Windows.) Next we supply the instance handle, and we specify in the style field that we want the window to be redrawn if it is resized either vertically or horizontally. Finally, we name a long pointer to **MainWndProc**, which Windows will call when it has a message for the application.

There are two other fields in the structure that we have left at zero, namely the class- and window-extra data. By asking for space here, the programmer can store useful information common to the class or unique to each window in the class.

If the registration is successful, we then unlock and free the memory used and return TRUE.

In the registration procedure, we obtained the class name by reading it from the resource segment. If this is a second or later instance of the program, it is not necessary to register the class again. Nevertheless, we still need the application name as well as several other strings in the program, and we want a handle to the special font we require. We load this data from a previous instance of the program.

Now we are ready to create the window. If this is the first instance, we want the window to show up in the lower right hand corner of the screen. In addition, we require that the window be large enough to display one line of text of the form

```
hh:mm:ss A.{P.}M.
```

This string requires 13 characters. Clearly, we must be able to create a window with a client area (the region in which the application can draw) one character high and at least 13 characters wide. In addition, we have to measure the screen size (in pixels) so that we can properly place the window of the first instance. To obtain this information we need a display context for the screen. Normally, a window display context is obtained from the window handle, but as we have not created the window, the handle is not yet available. But we can always get an "Information Context" for the display. We can then read the size of the default font with the **GetTextMetrics** call and obtain the essential screen data with **GetDeviceCaps**. After that, the information context can be deleted.

The next step is to find out how big the Window must be in order for the client area to have the desired size. To this end we fill out a rectangle with the desired location and size of the client and call **AdjustWindowRect** to get the actual window rectangle needed; however, because we have set the client area to be at the upper left corner of the screen, the coordinates of the window's upper left corner will be negative. This may explain the peculiar mathematics involved in actually calculating the values of the variables **width** and

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height, which are then passed to the **CreateWindow** call.

To generate a window of the class we have just registered, we have to supply Windows with additional information through the **CreateWindow** call. The window title is the same as the application's, which is just the class name. The style, which we have already defined when adjusting the client rectangle, is typical of a program's top level window. The only deviation from the standard WS_OVERLAPPEDWINDOW style is in not allowing a MAXIMIZE box.

Although we want to place the first instance of the window in a particular place, all subsequent instances need to appear somewhere else. (Otherwise, you will see only the most recent instance as one will be superimposed upon the other!) So we simply accept the default location by entering CW_USEDEFAULT,0 for the coordinates of the upper left corner. But we do use the width and height so laboriously computed above. Since a top level window has no parent, we need no menu, and since we have no special data required during creation, these parameters are set to NULL.

If this is the first instance of the program and the creation is successful, we measure the window's actual size, which may differ from the requested value since most windows have a set of minimum dimensions. We combine the values found from **GetWindowRect** with the screen dimensions already found and move the window to the lower right corner of the screen.

Note that this code works for any display. Windows offers many calls to allow the programmer to write code in a device-independent way.

Finally, the window is displayed and updated. **UpdateWindow** is a request for Windows to send the application a WM_PAINT message. In many Windows programs, all output to the screen is done in response to this message. Usually, a program generates this output by (1) modifying some data structure used by its paint routine to draw on the screen and (2) marking as "invalid" the corresponding rectangle on the screen where this data will appear. Windows then sends a paint message, and the application updates the screen. Of course, an application can write to the screen whenever a display context can be obtained, but the indirect method just described is quite common, and we make extensive use of it in this program.

Currently, the icon window on a high resolution display such as the EGA is usually 36 pixels square and the standard font is 8 pixels wide and 10 pixels high. On a VGA or AT&T/Olivetti monochrome screen, the font is taller but has the same width. So if the system font is used, it would be impossible to show three lines, one of which has five characters, without clipping. But Windows has a variety of fonts that can be used. By describing the desired font in a logical font structure, we may be able to obtain one that is suitable. This is the purpose of **GetFontInfo**.

Because it is difficult to anticipate every device, we have made the width, height, and weight of the font selectable via the Windows initialization file **win.ini**. If the user has made the entries outlined in the "Description of the Program" earlier in this article, the **GetProfileInt** call will return the values specified. If they are not found, the default values will be used.

A complete discussion of the various parameters of the LOGFONT structure and how Windows makes the selection would take us far afield. You may want

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to experiment with some of the fields and observe the results. If you are curious, you can read the face name of the font you have found by getting a display context, selecting the font into it, and calling **GetTextFace**.

The Resident Module

At last, we can consider the main code segment (Listing 6). We begin by defining EXTERN so that all global variables are declared in this module. Following are the declarations of two static structures. The first is needed to read the time. The second is a rectangle the coordinates of whose lower right corner are updated each time the window is moved. This rectangle always contains the dimensions of the client and is used to center text in the window.

The entry point for all Windows programs is **WinMain**. We have already described the parameters passed to **WinMain**. As you can see, ours simply calls the initialization function and then falls into the so-called message reading loop used in one form or another by every Windows program. The program stays there until **GetMessage** returns zero. **WinMain** then returns, causing the program to exit.

A typical non-Windows program gets input by querying the operating system. A windowing system, by contrast, waits for information to arrive in the form of messages. These are retrieved until the application's message queue is empty. Control then passes to another program, and the application remains suspended until a message is again available. If a message is retrieved, it is translated (an action that converts WM_KEYDOWN and WM_KEYUP messages to WM_CHAR messages and which is analogous to obtaining an ASCII value from a scan code) and then dispatched to the application's window procedure. Windows then calls the window procedure that carries out the appropriate task and returns.

Note that if an application doesn't read messages, no other process can run. Although multitasking, Windows is not preemptive. In addition, the **GetMessage** call does not return until a message is available, and it may appear that no Windows program can carry on lengthy operations in its Windows procedure. In fact, there are methods to maintain tasking using **PeekMessage**. In the future, we will try to give some examples of this kind of message handling.

Over a hundred different kinds of messages can be sent to a program. Mouse movement, mouse button clicks, keyboard action, windows movement and sizing, requests for painting, etc.—all generate messages. Each contains data in the word parameter (**wParam**) and long parameter (**lParam**), whose meanings are unique to the message. Most messages are never specifically acted upon by a program and are simply returned for default processing. In our program, we take special action on only five messages.

A WM_CREATE message is received when the corresponding window has been created but not yet displayed. This is an appropriate opportunity to perform certain initializations. Here we use it to read the time because as soon as the window shows itself it will receive a WM_PAINT message, as well. As this is the signal to display the time, it is necessary to have current data already available.

The WM_DESTROY message is the signal that the application has received a request to exit. The timer is killed, and a request is made to Windows to post a quit message to the program. When the quit message is received, **GetMessage** will return zero in the message loop and the program will exit.

A WM_SIZE message is sent whenever the window changes size. **lParam** contains the new client width and height in its respective low and high word. As we are using the window client rectangle to center text when we display the time, we need to know when this information changes.

We have set the timer to send us a WM_TIMER message about once a second. When the message arrives, we get the time. If there is an hour change, we invalidate the client area of the window and request that the background be repainted as well. If we are iconic, we record the time but do not invalidate the window client area unless the minute has changed. If not iconic, the rectangle is invalidated since we are showing the seconds, as well. Note that in the latter case we request that the background *not* be updated in order to avoid the unpleasant flashing this can cause on the screen.

The **InvalidateRect** call causes a WM_PAINT message to be placed in the message queue. The first action an

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application takes is to retrieve a paint structure using the **BeginPaint** function. This is passed to our paint routine, where all updating is performed. The **EndPaint** call terminates a paint message. Even if an application has no local paint function, these two function calls must be executed whenever a paint message is received.

Included in the paint structure passed to **MainWndPaint** is a handle to a "Display Context," which must be obtained from Windows before any output can be performed. A display context is basically a data structure describing the objects to be used when drawing on the output device. The device itself can be a printer, the screen, or even a memory bitmap. A display context has a number of default characteristics such as a black pen, white brush, system font, text mapping mode, etc. If the application wants something different, such as a color brush or a different font, these must be selected into the display context. So one of our first actions is to see if we are iconic. If so, the small font, whose handle we retrieved during initialization, is selected; otherwise, we accept the system font.

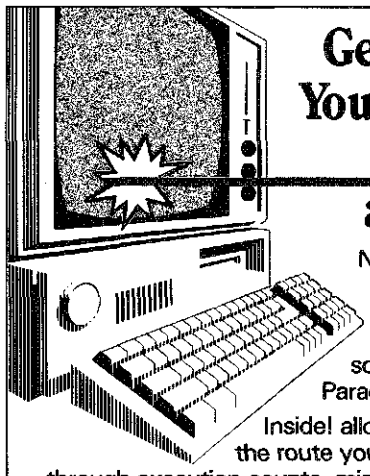
Most of the remainder of this last routine is straightforward. The last step is finally to draw the text using the client rectangle of the window. Although many different styles are possible, the ones we have specified suffice for either the icon or normal window.

DC As a Template

Now you see how a simple Windows program is constructed. It is not very easy to write even a small one, but a lot of the work is simply boilerplate. For example, every program has to register its window class and create one or more windows, read messages, and respond to a selected subset of them. Everything else is an enhancement and extension of this basic pattern tailored to the overall purpose of the program.

For example, DC can be stripped down to form a template that you can use as a basis for your own programs. Here is a suggested list of steps:

1. Remove all strings from the resource file except the application name.
2. Change the description string in the .DEF file to something more appropriate.
3. Delete all string constant definitions in the header file except the first. Also, remove all external variables except the handle to the main window and the application name string.
4. In **dc.c**, delete the static variables at the top and in the window procedure. Remove the case statements for WM_TIMER, WM_CREATE, and WM_SIZE. Delete the timer call in WM_DESTROY, all references to **MainWndPaint**, and the procedure itself.
5. In **dcinit.c**, take out **GetFontInfo** and any references to it. Remove the **LoadString** and **SetTimer** calls in **InitProgram**. Load only the **AppName** string in **GetPreviousInstanceData**. Finally, in **MakeAndShowMainWnd**, delete all code prior to the **CreateWindow** call. Substitute WS_OVERLAPPEDWINDOW for style and CS_USEDEFAULT,0 for width and height. And eliminate the special positioning code used for the first instance.
6. Make and test the result. If the program runs and supports more than one instance, you can then rename all



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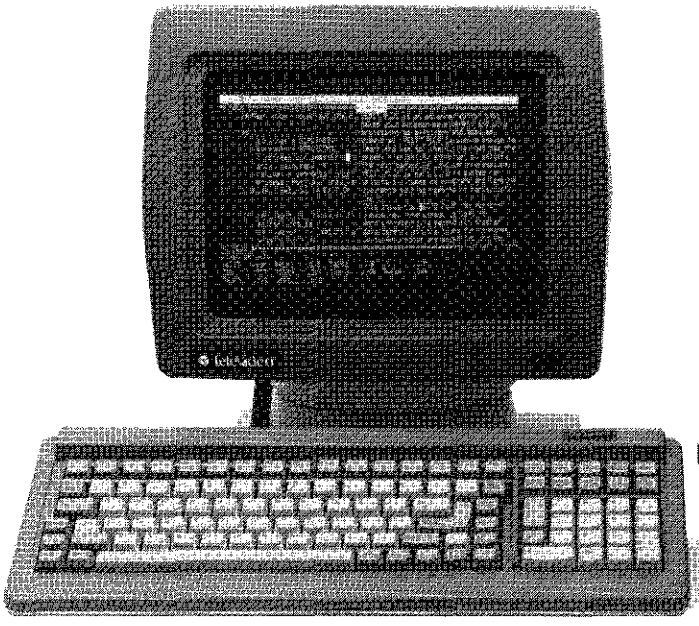

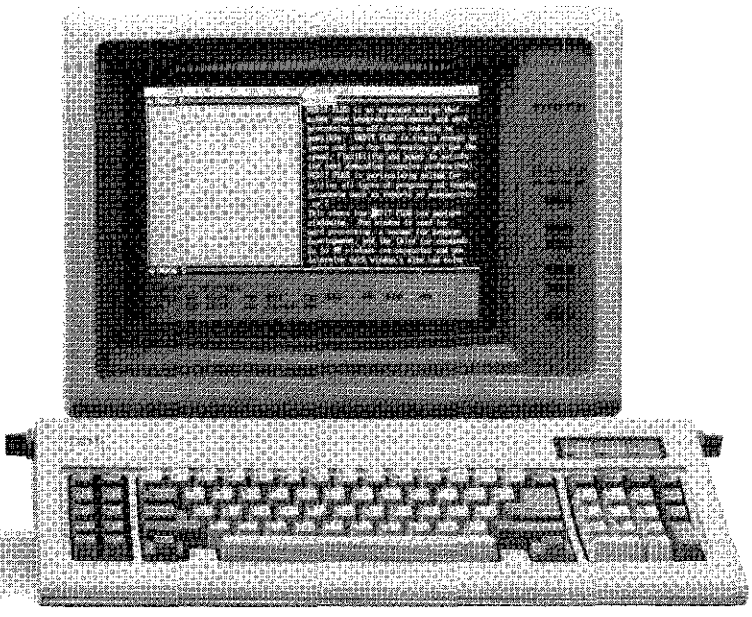

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files to something more appropriate, say SMLTPL*.*, making sure that the corresponding name changes are also made in the source, definition, make, and resource files. You now have a segmented, small-model template that you can use for your future efforts. ♦

Michael J. Babcock has directed electronic and computer music facilities while teaching electronic music composition as well as acoustics, audio, and traditional music theory. Mr. Babcock programs music synthesis/MIDI applications with Atari/GEM and serves on the ANSI X3H3 Computer Graphics Standards Committee. He is currently a Windows Systems Engineer for Olivetti in Cupertino, California.

William S. Hall holds degrees from the University of Virginia, Cambridge University, Brown University, and the University of Michigan. He taught college mathematics and worked for three years as an associate editor of Mathematical Review. *He is a Senior Engineer at Olivetti Advanced Technology Center in Cupertino, California, where he specializes in Windows system support software.*

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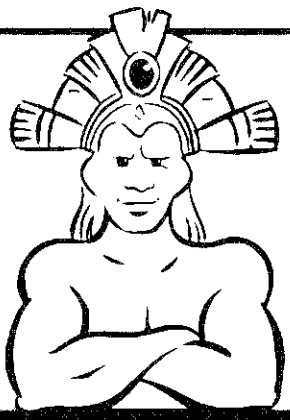

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Code from "Digital Clock" by Babcock & Hall

1

Listing 1

```
## DC - Windows Digital Clock
# Created by Michael Babcock and Bill Hall
#

## some macros
# no debug compile
cp=cl -d -c -AS -Gw -Ox -Zp

# debug compile
cpd=cl -d -c -AS -Gw -Zpd

# Microsoft C 5.x compiler with OS2 libraries
LIBOS2=slibw slibc slibc3 libh/NOD/NOE

# Microsoft C 5.x compiler with PM libraries
LIBPM=slibw slibcr libh/NOD/NOE

# Microsoft C 5.0 compiler for MS-DOS
LIB5=slibw slibc libh/NOD/NOE

# Microsoft C 4.0 compiler for MS-DOS
LIB4=slibw slibc libh/NOD

## make the .RES file
dc.res : dc.rc dc.h
    rc -r dc.rc

## make the .OBJ files
dc.obj : dc.c dc.h
    $(cp) -NT _TEXT dc.c

dcinit.obj : dcinit.c dc.h
    $(cp) -NT _INIT dcinit.c

## create the .EXE file, add resources, and make a map file
dc.exe : dc dc.def dc.res dc.obj dcinit.obj
    link4 dc dcinit,dc/align:16,dc/m/li,$(LIBPM),dc
    rc dc.res
    mapsym dc
```

Listing 2

```
NAME    DC

DESCRIPTION 'Windows Digital Clock by Mike Babcock and Bill Hall'

STUB 'Winstub.exe'

HEAPSIZE        1024
STACKSIZE       4096

CODE    MOVEABLE
DATA    MOVEABLE MULTIPLE

SEGMENTS
    _TEXT PRELOAD MOVEABLE
    _INIT PRELOAD MOVEABLE DISCARDABLE

EXPORTS
    MainWndProc @1
```

Listing 3

```
#include "dc.h"
```

2

```
STRINGTABLE
BEGIN
    IDS_APPNAME,        "DC"
    IDS_DISPLAYNAME     "DISPLAY"
    IDS_TIMESTR         "TIME"
    IDS_AM              "A.M."
    IDS_PM              "P.M."
    IDS_FONTHEIGHT      "fontheight"
    IDS_FONTWIDTH       "fontwidth"
    IDS_FONTWEIGHT      "fontweight"
END
```

Listing 4

```
/*
 * Header file for the digital clock.
 *
 * Written by Michael Babcock and Bill Hall
 * April 20, 1988
 *
 */

/* This trick insures that globals are declared in only one place */
#if !defined(EXTERN)
#define EXTERN extern
#endif

/* Declarations which need to be known in all C source files */
LONG FAR PASCAL MainWndProc(HWND,unsigned,WORD,LONG);
BOOL FAR InitProgram(HANDLE, HANDLE, LPSTR, int);

/* Resource string constants */
#define IDS_APPNAME     100
#define IDS_DISPLAYNAME 101
#define IDS_TIMESTR     102
#define IDS_AM          103
#define IDS_PM          104
#define IDS_FONTWIDTH   105
#define IDS_FONTHEIGHT  106
#define IDS_FONTWEIGHT  107

/* Global variables */
EXTERN HWND hWndMain;           /* main window handle */
EXTERN HFONT hFont;             /* handle to font used when drawing in icon */
EXTERN WORD ClockTimerEventID;  /* timer event identifier */
EXTERN char szAppName[10];      /* name of the application */
EXTERN char szTimestr[10];      /* icon title string */
EXTERN char szAM[10];           /* A. M. string */
EXTERN char szPM[10];           /* P. M. string */
```

Listing 5

```
/*
  Initialization segment for the digital clock.
  This code can be discarded after it is used.
 */

#include <windows.h>
#include "dc.h"

/* local function declarations */
static BOOL NEAR RegisterWindowClass(HANDLE);
static HFONT NEAR GetFontInfo(HANDLE);
static void NEAR GetPrevInstanceData(HANDLE);
static BOOL NEAR MakeAndShowMainWnd(HANDLE, HANDLE, int);

/* This routine is FAR since it is called from another segment */
BOOL FAR InitProgram(hInstance,hPrevInstance, lpszCmdLine, cmdShow)
HANDLE hInstance, hPrevInstance;
LPSTR lpszCmdLine;
int cmdShow;
{

  /* if this is the first instance of the program ... */
```


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```
    if (!hPrevInstance) {
      /* read some strings from the resources */
        LoadString(hInstance,IDS_TIMESTR,(LPSTR)szTimestr,sizeof(szTimestr));
        LoadString(hInstance,IDS_AM,(LPSTR)szAM,sizeof(szAM));
        LoadString(hInstance,IDS_PM,(LPSTR)szPM,sizeof(szPM));
      /* register the window */
        if (!RegisterWindowClass(hInstance))
            return FALSE;
      /* get a font for displaying the time in the icon window */
        if ((hFont = GetFontInfo(hInstance)) == NULL)
            return FALSE;
    }
  /* A previous instance already exists so get global data from there */
    else
        GetPrevInstanceData(hPrevInstance);

  /* Create and show the window */
    if (!MakeAndShowMainWnd(hInstance,hPrevInstance, cmdShow))
        return FALSE;

  /* Set the timer to generate a WM_TIMER message about once a second */
    if (!(ClockTimerEventID = SetTimer(hWndMain, NULL, 975, NULL)))
                /* at 1000 msec, clock skips a second every 24 seconds;   */
                /* at  975 msec, clock repeats a second every 87 seconds  */
        return FALSE;

    return TRUE;
}

/* Every window must belong to a class. We register ours here */
static BOOL NEAR RegisterWindowClass(hInstance)
HANDLE hInstance;
{

    PWNDCLASS pWndClass;
    HANDLE hTemp;

  /* Load the name string from resources */
    LoadString(hInstance, IDS_APPNAME,(LPSTR)szAppName,sizeof(szAppName));

  /* allocate space for the WNDCLASS structure and lock it down */
    hTemp = LocalAlloc(LPTR,sizeof(WNDCLASS));
    pWndClass = (PWNDCLASS)LocalLock(hTemp);

  /* fill the structure */
    pWndClass->hCursor  = LoadCursor(NULL, IDC_ARROW);  /* standard cursor */
    pWndClass->hIcon    = NULL;                         /* no icon */
    pWndClass->lpszMenuName = NULL;                     /* no class menu */
    pWndClass->lpszClassName = (LPSTR)szAppName;        /* our class name */
    pWndClass->hbrBackground = GetStockObject(WHITE_BRUSH); /*white background*/
    pWndClass->hInstance = hInstance;           /* instance handle */
    pWndClass->style = CS_VREDRAW | CS_HREDRAW; /* standard redraw values */
    pWndClass->lpfnWndProc = MainWndProc;       /* pointer to our window proc */

  /* register the class.  if fail, abort */
    if (!RegisterClass((LPWNDCLASS)pWndClass))
        return FALSE;

  /* free the memory used */
    LocalUnlock(hTemp);
    LocalFree(hTemp);

  /* show success */
    return TRUE;
}

/*
   If this not the first instance, we can retrieve static data from a
   previous invocation of the program
*/
static void NEAR GetPrevInstanceData(hInstance)
HANDLE hInstance;
{

    GetInstanceData(hInstance, (PSTR)szAppName, sizeof(szAppName));
    GetInstanceData(hInstance, (PSTR)szTimestr, sizeof(szTimestr));
    GetInstanceData(hInstance, (PSTR)szAM, sizeof(szAM));
    GetInstanceData(hInstance, (PSTR)szPM, sizeof(szPM));
```



```
    GetInstanceData(hInstance, (PSTR)&hFont, sizeof(HFONT));
}

/*
 Create the window, making sure that its position and size are suitable
 for the display.
*/
static BOOL NEAR MakeAndShowMainWnd(hInstance, hPrevInstance, cmdShow)
HANDLE hInstance;
HANDLE hPrevInstance;
int cmdShow;
{

    DWORD style;
    RECT clrect;
    HDC hIC;
    char szDisplayName[20];
    TEXTMETRIC TM;
    int displaywidth, displayheight;
    int width, height;

  /* First, create an information context for the display */
    LoadString(hInstance, IDS_DISPLAYNAME,
                          (LPSTR)szDisplayName,sizeof(szDisplayName));
    hIC = CreateIC((LPSTR)szDisplayName,(LPSTR)NULL, (LPSTR)NULL, (LPSTR)NULL);
  /* Now get the size of the system font */
    GetTextMetrics(hIC, (LPTEXTMETRIC)&TM);
  /* Also, retrieve information about the width and height of the display */
    displayheight = GetDeviceCaps(hIC, VERTRES);
    displaywidth = GetDeviceCaps(hIC, HORZRES);
  /* delete what we no longer need */
    DeleteDC(hIC);
  /*
     Now we specify the client window we would like to have.  However,
     its position is only nominal and later we will move it.  What we
     really want is the size of the window we need to create to achieve
     the desired client area.  Since the display is one line, the client
     must be high enough to display it.  And, since the text is an
     expression of the form hh:mm:ss A.(P.)M., it must be at least 13
     characters wide.
   */
    clrect.left = 0;
    clrect.top = 0;
    clrect.right = TM.tmAveCharWidth * 13;
    clrect.bottom = TM.tmHeight + TM.tmExternalLeading;

  /* this is the style we want */
    style = WS_OVERLAPPED | WS_MINIMIZEBOX | WS_CAPTION | WS_SYSMENU
                          | WS_THICKFRAME;
  /* adjust the rectangle to the actual window size */
    AdjustWindowRect((LPRECT)&clrect, style, FALSE);
  /* now compute the actual client width and height */
    width = clrect.right - clrect.left;
    height = clrect.bottom - clrect.top;
  /* create the window, letting it fall where Windows wants */
    hWndMain = CreateWindow((LPSTR)szAppName,
                            (LPSTR)szAppName,
                            style,
                            CW_USEDEFAULT,0,
                            width, height,
                            (HWND)NULL,
                            (HMENU)NULL,
                            (HANDLE)hInstance,
                            (LPSTR)NULL);

  /* if we fail, give up */
    if (hWndMain == NULL)
        return FALSE;
  /*
     if this is the first instance, we move the window
     to the lower right corner.
  */
    if (!hPrevInstance) {
      /* first, find out where we are */
        GetWindowRect(hWndMain, (LPRECT)&clrect);
      /* compute the width and height */
        width = clrect.right - clrect.left;
        height = clrect.bottom - clrect.top;
```

1988 Programmer's Journal 6.4

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Babcock & Hall, Continued

```
    /* now move the window down to the right corner */
       MoveWindow(hWndMain, displaywidth - width, displayheight - height,
                  width, height,FALSE);
       }
    /* finally, display the window and show success */
       ShowWindow(hWndMain, cmdShow);
       UpdateWindow(hWndMain);

       return TRUE;

    }
    /*
       Create a logical font that is suitable for displaying the time
       in our format when the window is iconic.  Since the font weight
       and size will depend on the display in use, three of the parameters
       can be read from WIN.INI.  For CGA type displays, try using a
       height of 6, a width of 4, and a weight of 400.  For the EGA,
       values of 8, 6, and 700 (the defaults) are satisfactory.
    */
    static HFONT NEAR GetFontInfo(hInstance)
    HANDLE hInstance;
    {
       char szKeystr[30];
       /* fill this structure with the font characteristics we want */
       LOGFONT clockfont;
       HFONT htemp;
       /* read the height from Win.ini */
       LoadString(hInstance,IDS_FONTHEIGHT,(LPSTR)szKeystr, sizeof(szKeystr));
       clockfont.lfHeight = GetProfileInt((LPSTR)szAppName, (LPSTR)szKeystr,8);

       /* read the width from Win.ini */
       LoadString(hInstance,IDS_FONTWIDTH,(LPSTR)szKeystr, sizeof(szKeystr));
       clockfont.lfWidth = GetProfileInt((LPSTR)szAppName, (LPSTR)szKeystr,6);

       /* read the weight from Win.ini */
       LoadString(hInstance,IDS_FONTWEIGHT,(LPSTR)szKeystr, sizeof(szKeystr));
       clockfont.lfWeight = GetProfileInt((LPSTR)szAppName, (LPSTR)szKeystr,700);

       /* default these values */
       clockfont.lfEscapement = 0;
       clockfont.lfOrientation = 0;
       clockfont.lfItalic = 0;
       clockfont.lfUnderline = 0;
       clockfont.lfStrikeOut = 0;
       clockfont.lfCharSet = ANSI_CHARSET;
       clockfont.lfOutPrecision = OUT_DEFAULT_PRECIS;
       clockfont.lfClipPrecision = CLIP_DEFAULT_PRECIS;
       clockfont.lfQuality = DEFAULT_QUALITY;
       clockfont.lfPitchAndFamily = FIXED_PITCH | FF_MODERN;
       clockfont.lfFaceName[0] = 0;

       /* get the handle to the font */

       return(CreateFontIndirect((LPLOGFONT)&clockfont));

    }
```

Listing 6

```
/*
   Resident segment for the Windows digital clock
*/

#include <windows.h>
#include <dos.h>
#include <string.h>

#define EXTERN          /* all global variables declared in this module */
#include "dc.h"

static struct dostime_t time;   /* holds the time parameters */
static RECT clrect;             /* formatting rectangle for time display */

/* local function declarations */
static void NEAR MainWndPaint(HWND, LPPAINTSTRUCT);
```


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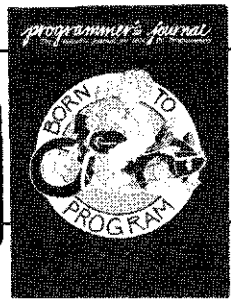

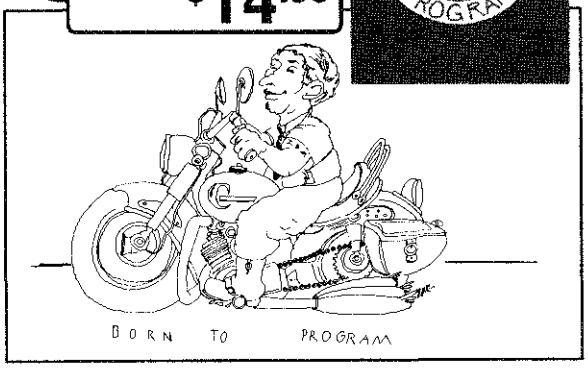

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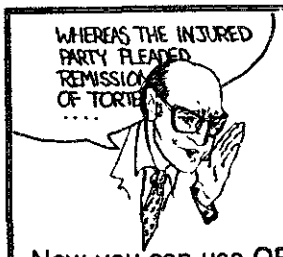

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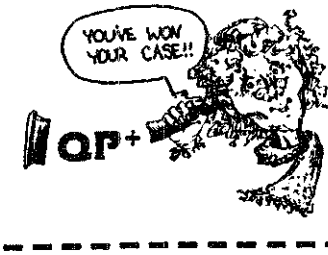

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Babcock & Hall, Continued

```
/* Entry point for program */
int PASCAL WinMain(hInstance, hPrevInstance, lpszCmdLine, cmdShow)
HANDLE hInstance, hPrevInstance;
LPSTR lpszCmdLine;
int cmdShow;
{
    MSG msg;

    /* If initialization is not successful then exit */
    if (!InitProgram(hInstance,hPrevInstance, lpszCmdLine, cmdShow))
        return FALSE;

    /* Retrieve messages from Windows */
    while (GetMessage((LPMSG)&msg,NULL,0,0)) {
        TranslateMessage((LPMSG)&msg);
        DispatchMessage((LPMSG)&msg);
    }
    return msg.wParam;          /* exit program */
}

/* All messages are processed here */
long FAR PASCAL MainWndProc(hWnd,message,wParam,lParam)
HWND hWnd;
unsigned message;
WORD wParam;
LONG lParam;
{
    PAINTSTRUCT ps;

    static BYTE prevminute = 0;          /* these values control updating */
    static BYTE prevhour = 0;

    switch(message) {
      /* initialize the time structure when window is created */
      case WM_CREATE:
          dos_gettime(&time);
          break;

      /* we are exiting, so kill the timer and post a quit message */
      case WM_DESTROY:
          KillTimer(hWnd, ClockTimerEventID);
          PostQuitMessage(0);
          break;

      /* keep a record of the window size for use by the paint function */
      case WM_SIZE:
          clrect.right = LOWORD(lParam);
          clrect.bottom = HIWORD(lParam);
          break;

      /* Each timer event comes here for processing */
      case WM_TIMER:
          dos_gettime(&time);
        /* if new hour, erase window and redisplay the time */
          if (prevhour != time.hour)
              InvalidateRect(hWnd, (LPRECT)NULL, TRUE);
        /* otherwise, just redisplay the time without erasing background */
          else {
              if (IsIconic(hWnd)) {
                /* but, when iconic, do this only on a minute change */
                  if (prevminute != time.minute)
                      InvalidateRect(hWnd, (LPRECT)NULL, FALSE);
              }
              /* and if not iconic, display every second */
              else
                  InvalidateRect(hWnd, (LPRECT)NULL, FALSE);
          }
          prevminute = time.minute;    /* save the new values */
          prevhour = time.hour;
          break;

      /* we have to update the window */
      case WM_PAINT:
          BeginPaint(hWnd, (LPPAINTSTRUCT)&ps);
          MainWndPaint(hWnd, (LPPAINTSTRUCT)&ps);
          EndPaint(hWnd, (LPPAINTSTRUCT)&ps);
```


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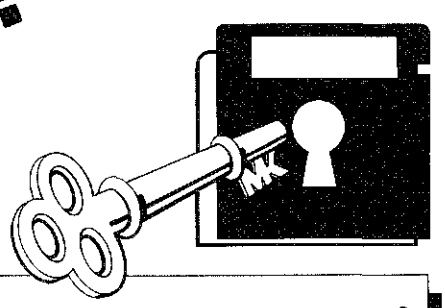

turn this into this!

```
C:\>DEBUG PROGRAM.COM
-D100 136
8648:0100  EB 18 49 6E 63 6F 72 72-65 63 74 20 44 4F 53 20  k.Incorrect DOS
8648:0110  76 65 72 73 69 6F 6E 0D-0A 24 50 B4 30 CD 21 86  version..$P40N!.
8648:0120  E0 3D 36 01 72 05 3D 0A-02 76 09 BA 02 01 B4 09  `=6.r.=..v.:..4.
8648:0130  CD 21 CD 20 58 EB 2F                             M!M Xk/
-Q
```

```
H00100: JMP     Short H0011A                    ;00100 EB18          __
;---------------------------------------------
        DB      "Incorrect DOS version"         ;00102 496E636F727265
        DB      0Dh                             ;00117
        DB      0Ah                             ;00118
        DB      "$"                             ;00119 24            $
;---------------------------------------------
H0011A: PUSH    AX                              ;0011A 50            P
        MOV     AH,30h                          ;0011B B430          _0
        INT     21h             ;1-DOS_Ver_Number ;0011D CD21        _!
        XCHG    AH,AL                           ;0011F 86E0          __
        CMP     AX,0136h                        ;00121 3D3601        =6_
        JB      H0012B          ; . . . . . .   ;00124 7205          r_
        CMP     AX,020Ah                        ;00126 3D0A02        =__
        JBE     H00134          ; . . . . . .   ;00129 7609          v_
H0012B: MOV     DX,0102h                        ;0012B BA0201        :__
        MOV     AH,09h                          ;0012E B409          __
        INT     21h             ;1-Display_String ;00130 CD21        _!
        INT     20h             ;TERM_normally:20h ;00132 CD20       _
;---------------------------------------------
H00134: POP     AX                              ;00134 58            X
        JMP     Short H00166                    ;00135 EB2F          _/
;---------------------------------------------


MASTER*KEY XREF - PROGRAM.XRF                                  Page 1

0102h                   :   121   2F5   301   320
020Ah                   :   126
03CBh                   :   12B
1-Display_String        :   130   591   610
1-DOS_Ver_Number        :   11D
H00100                  :   100
H0011A                  :   100   11A
H0012B                  :   124   12B
H00134                  :   129   134
H00166                  :   135
TERM_normally:20h       :   132
```

NOTE: The cross-reference is by memory location within the program file!

NOTE: The output is totally Microsoft MASM-compatible.

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7

```
        break;

    /* all other messages come here */
    default:
        return ((long)DefWindowProc(hWnd,message,wParam,lParam));
        break;
    }
    return(0L);
}

/* Create a text string with the time and display it */
static void NEAR MainWndPaint(hWnd, lpps)
HWND hWnd;
LPPAINTSTRUCT lpps;
{
    char szTimeText[40];
    int i;
    BOOL iconic = IsIconic(hWnd);
    BYTE hour = time.hour;
    BYTE minute = time.minute;
    BYTE second = time.second;

    if (hour > 12)                  /* 12-hour display, i. e. 12:30 not 00:30 */
      hour -= 12;
    if (hour < 1)
      hour = 12;

    if (iconic) {
      strcpy(szTimeText, szTimestr);        /* Give icon display a title */
      i = strlen(szTimeText);
      szTimeText[i++] = '\n';               /* Force a new line */
      SelectObject(lpps->hdc, hFont);       /* Select in the small font */
    }
    else
      i = 0;

    if (hour > 9)                           /* ...hour...*/
      szTimeText[i++] = '1';
    szTimeText[i++] = hour % 10 + '0';
    szTimeText[i++] = ':';                  /* ...minute... */
    szTimeText[i++] = minute > 9 ? minute / 10 + '0' : '0';
    szTimeText[i++] = minute % 10 + '0';
    if (!iconic) {                          /* ...second...*/
      szTimeText[i++] = ':';
      szTimeText[i++] = second > 9 ? second / 10 + '0': '0';
      szTimeText[i++] = second % 10 + '0';
    }
    if (iconic)                             /* force another line if iconic */
      szTimeText[i++] = '\n';
    else                                    /* otherwise make a space */
      szTimeText[i++] = ' ';
    szTimeText[i] = '\0';

    if (time.hour > 11)                     /* morning or afternoon */
      strcat(szTimeText, szPM);
    else
      strcat(szTimeText, szAM);

    /* display the text */
    DrawText(lpps->hdc, (LPSTR)szTimeText, -1, (LPRECT)&clrect,
                        DT_NOCLIP | DT_EXTERNALLEADING | DT_CENTER);
}
```


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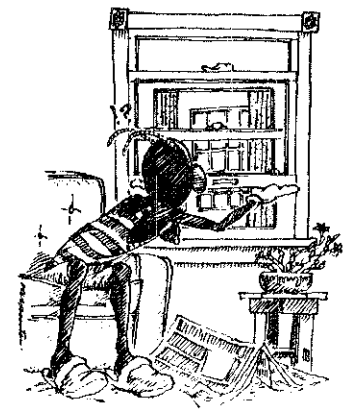
Windows within Windows

by
John Navas II



Turbo C Version 1.0 quickly established Borland International as a major player in the C game. With Version 1.5, Borland upped the ante by including a video library that in some ways is even more powerful than the graphics library supplied with QuickC Version 1.0 from archrival Microsoft. The Turbo C video library includes not only graphic support, but also windowed text functions that can be used to create a powerful user interface for non-graphic applications. Let's take a close look at some of the innermost workings of these text functions.

The Turbo C library provides two different kinds of video output, controlled by the external variable **directvideo**. If **directvideo** is non-zero (the default), output will be written directly to the video screen; if **directvideo** is set to zero, output will be routed through the video BIOS. This gives the programmer the familiar choices of either speed (direct video) or compatibility (BIOS video).

Given that direct video is much faster than BIOS video and that direct video will work on virtually all IBM PC-compatibles, is there any point in using BIOS video? Yes. Direct video is considered "poorly-behaved" because it normally prevents software from performing properly in windowing, multitasking environments like TopView from IBM, the popular DESQview from Quarterdeck Office Systems, or Microsoft Windows. BIOS video solves the problem, but it has the drawback of further slowing down programs that already run more slowly in a multitasking environment.

Many programmers believe that these are the only two video alternatives. But there is a third alternative, one which provides fast text video that is "well-behaved" and fully compatible with both DOS and windowing environments. This third alternative is actually a hybrid of the other two since it uses special video BIOS functions to locate the memory to be used for direct video output. These video BIOS extensions were introduced by IBM as part of TopView, and both DESQview and Microsoft Windows support them as well. (All references to TopView below also apply to DESQview and Windows.)

TopView Video BIOS Extensions

Get Video Buffer is the key to the third alternative. **Get Video Buffer** must be called with the function number (FEh) in the AH register and the address of the real video screen (B000:0000h for a monochrome adapter; otherwise B800:0000h) in the ES:DI register pair; the address of the video buffer is returned in the same ES:DI register pair. If TopView windowing is active, a shadow buffer is assigned to each window and the address of that buffer is returned. The program then writes to the shadow buffer (which of course does not affect the real screen directly). If TopView windowing is not active, the buffer address is not changed, so the program will simply write to the real video screen automatically. [This is also an undocumented call supported by Microsoft Windows.—Ed.]

Update Video Buffer is used to inform TopView that part or all of the shadow buffer has changed. **Update Video Buffer** must be called with the function number (FFh) in the AH register, the address of the first character in the buffer that has been modified in the ES:DI register pair, and the count of consecutive characters that have been modified in the CX register. TopView is responsible for copying the appropriate characters (and attributes) from the shadow buffer to the real screen. If TopView windowing is not active, the function has no effect (and is not needed).

If no more than a few characters are to be changed, **Update Video Buffer** may be called once for each character; otherwise, it is more efficient to wait and make a single call for multiple changed characters—or even the entire shadow buffer.

Unlike TopView, DESQview automatically updates the real screen even if **Update Video Buffer** is not used. (However, the function call should always be included to maintain TopView compatibility.) On the other hand, even if **Update Video Buffer** is used, Windows won't update the real screen until your program relinquishes control. A good way to do that is to simply call DOS to check for keyboard input.

Note that the TopView extensions may be used only in text (not in graphic) modes.

Good News in Turbo C

Whew! Sounds pretty complex, doesn't it? If only Borland had seen fit to build this third alternative into the Turbo library—but no such luck. So the trick is to fool Turbo into using the TopView shadow buffer. Happily, once you know the secret, that turns out to be rather easy since the Turbo library still does most of the work.

The key is the undocumented **_VIDEO** structure in the Turbo C

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library. (See the accompanying listing.) Whenever the screen is opened or the video mode is changed, Turbo stores all of the important video parameters in this structure, including the address of the video screen memory. If the address is changed—voila! Turbo will automatically write screen output to a buffer instead of to the actual screen.

The trick is to fool Turbo into using the windowing system's shadow buffer.

The function **SetupTopView()** takes care of changing the address (and shutting off the unnecessary CGA sync logic). **SetupTopView()** should be called at the start of a program and whenever the video mode is changed. Note that **SetupTopView()** also initializes the external char variable **TopViewActive** to non-zero if TopView windowing is active.

The other function, **UpdateTopView()**, is used to signal TopView to update the real screen from the shadow buffer. For simplicity's sake, **UpdateTopView()** specifies that the entire shadow buffer has changed. Used judiciously, this should not have a noticeable effect on performance.

So there you have it. Include these two simple functions in *all* your Turbo C programs, and you'll have "well-behaved" screen output (even windows within Windows) that is also very fast! ♦

John Navas II is a professional private computer consultant who specializes in high technology litigation. In the past seven years, John has worked for an international clientele that has included Intel and Hitachi.

The code from this article is available on 360K, MS-DOS disk, $10.00 postpaid. ORDER BY PHONE—VISA/MC orders call (503) 747-0800. Mail order information on page 76.

```
/*
**  FUNCTIONS THAT ALLOW TURBO C 1.5 VIDEO TEXT OUTPUT
**  ROUTINES TO RUN IN A TOPVIEW, DESQVIEW OR MICROSOFT
**  WINDOWS WINDOW, EVEN WHEN DIRECTVIDEO = 1.
*/

#include <conio.h>
#include <dos.h>

#define VIDEOINT    0x10    /* video BIOS interrupt */

extern struct _VIDEO {      /* UNDOCUMENTED VIDEO INFORMATION STRUCTURE */
    unsigned char winleft;      /* left window coordinate (0 relative) */
    unsigned char wintop;       /* top window coordinate (0 relative) */
    unsigned char winright;     /* right window coordinate (0 relative) */
    unsigned char winbottom;    /* bottom window coordinate (0 relative) */
    unsigned char attribute;    /* text attribute */
    unsigned char normattr;     /* normal attribute */
    unsigned char currmode;     /* current video text mode */
    unsigned char screenheight; /* bottom - top */
    unsigned char screenwidth;  /* right - left */
    unsigned char graphics;     /* mode type (0: text; 1: graphics) */
    unsigned char needcgasync;  /* cga sync to prevent "snow" (1: yes) */
    char far *videobuffer;      /* pointer to video buffer */
} _video;

char TopViewActive;         /* NON-ZERO IF TOPVIEW WINDOWING IS ACTIVE */

/*
**  SETUP FOR TOPVIEW/DESQVIEW VIDEO
**  call at startup and whenever the video mode is changed.
**  installs the shadow buffer address and sets TopViewActive.
*/
void SetupTopView(void)
{
    union REGS reg;
    struct SREGS sreg;

    if (_video.graphics) {                  /* if in a graphic mode */
       TopViewActive = 0;                  /* TopView cannot be active */
       return;
    }
    reg.h.ah = 0xFE;                        /* Get Video Buffer */
    sreg.es = FP_SEG(_video.videobuffer);   /* assumed buffer address */
    reg.x.di = FP_OFF(_video.videobuffer);
    int86x(VIDEOINT, &reg, &reg, &sreg);    /* call video BIOS */
    TopViewActive = (_video.videobuffer != MK_FP(sreg.es, reg.x.di));
    if (TopViewActive)                      /* if under TopView */
       _video.needcgasync = 0;              /* CGA sync is never needed */
    _video.videobuffer = MK_FP(sreg.es, reg.x.di);  /* shadow buffer addr */
}

/*
**  UPDATE SCREEN FROM TOPVIEW VIDEO BUFFER
**  (not required for DESQview)
*/
void UpdateTopView(void)
{
    union REGS reg;
    struct SREGS sreg;

    if (_video.graphics || !TopViewActive)  /* if graphic or not active */
    return;                                 /* TopView cannot be active */
    reg.h.ah = 0xFF;                        /* update video buffer */
    reg.x.cx = _video.screenheight * _video.screenwidth;    /* all of it */
    sreg.es = FP_SEG(_video.videobuffer);   /* buffer address */
    reg.x.di = FP_OFF(_video.videobuffer);
    int86x(VIDEOINT, &reg, &reg, &sreg);    /* call video BIOS */
    kbhit();                                /* yield Windows control */
}

/*
**  Test the TopView Video Functions.
*/

int main()
{
    int i;

    SetupTopView();
    cputs("This will run fine under DOS,"
       " as well as in a TopView/DESQview/Windows window!\n");
    UpdateTopView();
    for (i=1; i<=25; ++i) {
       sleep(1);
       cprintf("line %2d: %s\n", i,
           "ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz");
       UpdateTopView();
    }
    return 0;
}
```


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The Proposed ANSI C Language Standard

by
Rex Jaeschke

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Rex checks Microsoft C 5.1 and QuickC against the (still) emerging ANSI Standard.

Microsoft C V5.1

On page 3 of the *Microsoft C Language Reference* manual you'll find the following note: "Microsoft is committed to conformance with the developing standard for the C language as set forth in the Draft Proposed American National Standard—Programming Language C."

Having just completed an extensive look at C V5.1, I believe them. Note that this article is not intended to be a review of the whole product—just of its ANSI C features or lack thereof. The issue of OS/2 support has no impact on this review.

Microsoft admits that there are minor differences between V5.1 and the version of QuickC shipped with it, and I have indeed found this to be the case. Except where noted below, all comments pertain to the optimizing compiler.

The Compiler Options

You can define the signedness of **char** objects on a global basis using the /J switch or on an individual basis using the **signed** and **unsigned** type modifiers.

The compiler recognizes the first 31 characters of identifier names, and there seems to be no way to change this except via the /H switch, which applies only to external names. The linker has a switch to handle case sensitivity of externals. For maximum portability, make the link case-insensitive and restrict external names to 6 or 8 characters.

For warning messages, you can choose an appropriate level—I always use /W3, but you have nowhere near the level of granularity you have in Turbo C, which permits you to trace a whole set of message classes on an individual class basis. The /Za switch flags extensions and other non-standard constructs.

One of the *very best* switches I have seen on any C compiler is /Zg. This switch constructs function prototypes from existing source files and writes them to **stdout**. By redirecting the output to a file, you have the basis for a header you can then **#include** in the appropriate places. This permits you to take full advantage of prototypes in your existing code at the expense of including the header at the start of each source file. This option alone is worth the price of the whole kit, and I wish other vendors would follow suit. A minor point about **stdio.h**, though: In this header, FILE is defined as a macro rather than via **typedef**. So when you pass a FILE argument to a function, the prototype generated by / Zg is

```
extern int f(struct _iobuf infile);
```

instead of

```
extern int f(FILE infile);
```

The Preprocessor

Microsoft C V5.1 has all of the new preprocessor capabilities including **#pragma** (which they use heavily); **#error**; the **#include** identifier; the **#**, **##**, and **defined** operators; **#elif**; and the predefined macros __DATE__, __TIME__, and __STDC__, as well as __FILE__ and __LINE__. In ANSI mode, __STDC__ will be 1, and Microsoft has chosen to define it with a value of 0 since they cannot yet claim to be ANSI-conforming—there is no standard yet.

I was still able to fool the preprocessor with some extreme tests, but it came out with very high marks. It permits benign macro redefinitions as required by ANSI; that is, it flags a macro if it is already defined differently and accepts the macro otherwise. Consider the following example:

```
/*1*/ #define MACRO1 a macro
/*2*/ #define MACRO1 a macro
/*3*/ #define MACRO1 a   macro    /* spaces */
/*4*/ #define MACRO1 a      macro /* tabs */
/*5*/ #define MACRO1 example
```

The compiler complained only about #5 since it does have a different definition. All the others are equivalent *provided* you ignore white space (which ANSI permits). However, ANSI does *not* require white space to be ignored, so another ANSI-conforming compiler may legitimately complain about #3 and #4 above, as well.

Miscellaneous ANSI Features

The following ANSI features are supported:

- full function prototypes and new style function definitions
- **signed** keyword
- **const** and **volatile** type modifiers (although **volatile** has no semantics)

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- unary plus operator
- **void** functions
- concatenation of adjacent string literals
- the escape sequences **\xhhh**, **\a**, and **\v**
- the **long double** type
- **long double** and **float constants**
- generic pointers (**void ***)
- **%p** in **printf** for displaying pointers
- * mask in **printf** for variable field widths

The following ANSI features are not supported:

- trigraphs
- initialization of **auto** arrays and structures

The Runtime Library

All headers except **locale.h** (internationalization support) are provided. Except for those foreign language support functions recently added by ANSI, the V5.1 library seems to have the complete library, with the correct return types and argument lists. There are a few comments worth making, however:

- **assert** is implemented as a block statement, not as a **void** expression, and this prohibits its use in some situations.
- Surprisingly, **errno** is not declared in **errno.h**.
- Two macros are missing from **float.h**, and various other macros have been added (whose names are in the programmer's namespace).
- The integral minimum limits in **limits.h** are, unfortunately, not quite correct (at least in my opinion) even though they are ANSI-conforming. They reflect a ones-complement machine, and as such, CHAR_MIN is –127 instead of –128. Likewise for the other minima. I believe it is ANSI's intention that you specify your exact minima, not simply meet those specified by ANSI. I debated this with a Microsoft developer, and we had some disagreement.
- **stdarg.h** does not define the macro **offsetof**.
- **string.h** does not define the macro NULL.
- **math.h** has numerous macros whose names are in the programmer's namespace.
- **time.h** does not define the type **size_t**.

QuickC Notes

QuickC had the following limitations (not shared by the V5.1 compiler):

- can't handle macro definitions as large as the compiler can handle
- doesn't predefine __DATE__, __TIME__ and __STDC__
- permits __LINE__ and __FILE__ to be **#undefined**
- has no **#error**

In all other cases, it behaved as the compiler did.

Continued . . .

ANSI C Standard Meeting Report

Last week (April 18–22), I attended an ANSI C Standards Committee meeting in Nashua, New Hampshire. Late last year, it was our intent to vote the standard out at that meeting; however, that didn't happen.

At the December 1987, meeting in Austin, Texas, there was a last minute (last days, actually) push to incorporate some kind of syntax within a prototype to indicate to a compiler that the incoming arguments did not overlap. This was of particular interest to members implementing on systems with vector processing hardware. (Optimizers were also interested.)

As a result of this push, a palatable idea was proposed, and many of the more senior members of the committee worked into the wee hours over several days drafting precise language. The proposal was to add a new keyword, **noalias**, which would be a type specifier just like **const** and **volatile**. On the last day of the meeting, the **noalias** proposal was adopted, and we voted out the standard for its second public review—for a two month period. (Two members voted against this.)

Within days of that meeting's completion, word had reached the C community at large, and loud objections began to filter back to the committee. The most noticeable objection came from Dennis Ritchie, the principal designer of the C language. Not only did Dennis say he didn't like our solution, but he also submitted a public comment saying so and attended the Nashua meeting. (Interestingly, this was his first meeting.)

Dennis objected to the haste with which the keyword was added and didn't think it solved the problem. Dennis also thought it incorrect to use a type specifier as the solution. Dennis' final statement: "It must not survive."

Several others who had voted for **noalias** in December spoke out against it in April, and abetted by Dennis' persuasion, we voted **noalias**, and its associated baggage, out of the standard. The name **noalias** is now so tainted that it can never be used for anything again—it's cursed. Oh well, if you don't have bad, you can't have good.

All of this was achieved on the first day of the meeting. The rest of the week was dedicated to sifting through the several hundred pages of public comments. To expedite things, we broke into our usual 3–4 person subgroups. Each group had to screen their set of issues to identify those they thought needed full committee attention. While a few substantive changes were made to the draft, by far the largest number were editorial changes to both the draft and rationale documents.

On Friday morning, we again voted out the draft for another two month public review period. At the next meeting (August), we will repeat the same process as in Nashua (*sans* the **noalias** incident) and with a little luck could possibly vote out the final standard at that meeting. Of course, we could always choose (or be forced) to make one or more substantive changes, in which case, we go 'round again (and again, and again . . .)

In the meantime, I will be playing secretary at the next ISO C Standards meeting in London, UK, on June 13–14. P.J. Plauger, President of Whitesmiths, Ltd., is the convener. The meeting is to be held at the British Standards Institute.

To get a copy of the latest ANSI draft and rationale documents, contact Global Engineering Documents, Inc., by calling (800) 854-7179 or (714) 540-9870. Single copy price: US $65.00. Global Engineering are located in Santa Ana, California, USA, which is in the Pacific Standard Time (PST) zone.—RJ ♦

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The Bottom Line

Microsoft V5.1 comes very close to the draft ANSI Standard of December 1987, and is very well positioned to cover the home stretch when a standard is finally voted out. In the two biggest areas of historical discrepancy, the preprocessor and library, Microsoft gets an "A."

Since I looked at Turbo C V1.0 several issues ago, I have developed an extensive evaluation suite that stresses the preprocessor and library. I plan to subject other compilers to this suite, including Turbo C V1.5.

Future ANSI C Meetings

The schedule for future ANSI meetings: August 15–19, Cupertino, California (hosted by Borland, HP, and Tandem); and December 12–16, Seattle, Washington (hosted by Microsoft). ♦

Rex Jaeschke is an independent computer consultant, writer, and lecturer. He is also a member of the X3J11 C Standard's Committee, observer on the ISO C Standard's Committee, Founding Editor of the C Journal, *and the C language Editor of* DEC PROFESSIONAL. *Rex's new book* Portability and the C Language *will be published by Hayden in September. It is the first text on this popular topic.*

If you would like to comment on or question any aspect of the Proposed ANSI C Standard, write to

Rex Jaeschke
2051 Swans Neck Way
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Rex will endeavor to address your concerns in future columns as space permits.

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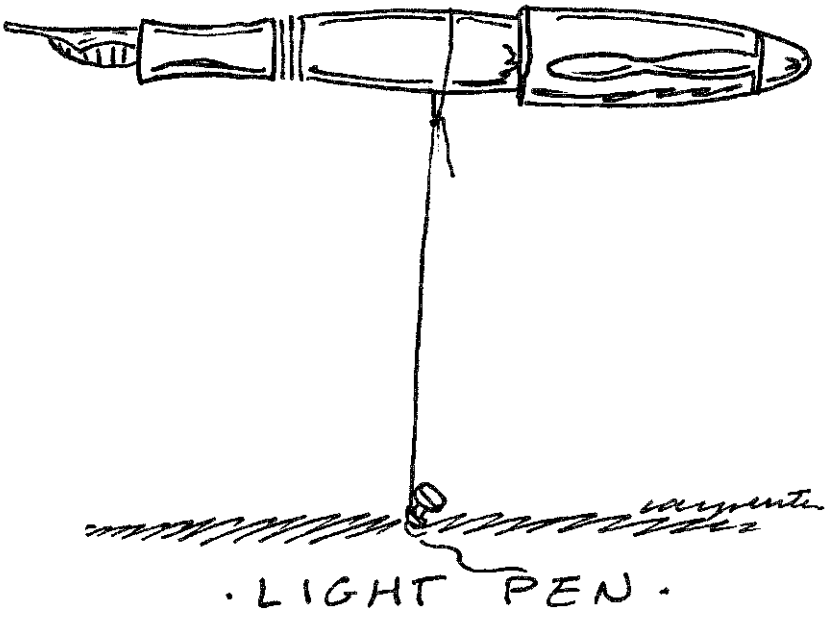

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Not a Creature Was Stirring . . .

by
John J. Newlin

. . . well, not until Apple introduced the mouse as a point and shoot device with the Macintosh. Now there are lots and lots of mice stirring around PCs. In fact, it's currently estimated that ten percent of the installed base of over 10 million PCs are equipped with mice. While that may seem to be a low percentage (the Macintosh boasts 100 percent), the main reason it's not higher is the low percentage of software that actually performs better with a mouse (about 2 percent).

Some programs today are much easier to use and therefore more efficient with a mouse interface, and at least one, Microsoft Word, practically requires one. Most CAD/CAM, paint, and draw programs are clumsy and difficult to use without a mouse. Microsoft Windows and the programs designed to run in that environment are severely hampered without a mouse, and I venture to say that you would be hard pressed to find anyone running desktop publishing software who does so without a mouse.

In my view, no programmer planning to incorporate a menu style user interface into his or her software can afford to ignore the mouse—especially because incorporating mouse support code is relatively simple and straightforward. After I ported Arcmaster to Turbo Pascal 4.0 and implemented a pull-down, pop-up menu interface, a user commented that the program "cried for a mouse interface." I don't particularly like to use a mouse, but I have one, and I could see that he was right. There's no doubt in my mind that the popularity of the program increased when I released the version that supported a mouse.

A Standard Driver Interface

One factor that greatly simplifies programming a mouse interface is that there is a standard. Mouse Systems was the first company to market a mouse for PCs, and they were followed shortly by Microsoft. Fortunately for programmers, even though the resident drivers offered by the different mouse manufacturers differ, the interface to those drivers is standard. The programmer doesn't have to worry about users equipped with four or five different brands of mouse hardware and software. The interface is interrupt driven, and as we shall see, very easy to exploit in the form of organic mouse code.

The mouse operates with all PC text and graphics modes. Except for the manner in which it handles the cursor, the mouse will react the same way in all modes. To the mouse, the screen is an array of 600 pixels by 200 pixels, the same as in the high resolution mode of the Color Graphics Adaptor (CGA). The mouse driver scales the pixel position (in *x*/*y* coordinates) according to the video mode. When in the CGA high resolution mode (600 x 200), the mouse provides a pixel by pixel report of the cursor position. In the CGA medium resolution mode, it scales the *x* position (horizontal) report by multiplying by two and reporting only the even numbered *x* coordinates. In the CGA 80 column text mode and monochrome mode, both the *x* and *y* coordinate positions should be reported in 8 pixel increments.

Cursor Handling

Cursor handling is a different story since the mouse driver supports three different types of cursors. The first of these is the normal hardware cursor controlled by the BIOS in the text mode. Control over the hard cursor is effected through calls to the video BIOS. The second cursor supported is the mouse soft cursor. The soft cursor is supported in the text mode, and the programmer can specify a cursor and a screen mask to produce a wide variety of cursor styles. The graphics cursor, the third cursor type supported, is available in the medium and high-resolution graphics modes. This cursor is controlled by a bit mask instead of a single character and therefore can be mapped accordingly into any shape that will fit into a 16 x 16 bit matrix. Both the soft and the graphics cursors can be turned on or off by the programmer through calls to the mouse interface. The PC hardware cursor can also be turned off by "hiding" it with a BIOS call.

Providing button release as well as button press information extends the programmer's control of the mouse environment.

Mouse Sensitivity

In this article, when I refer to *mouse sensitivity*, I'm talking about the ratio of mouse movement across the table (or pad) to the amount of corresponding cursor movement on the screen. As the mouse is physically moved, the mouse driver is sensing the mouse motion, transmitted either mechanically through action of the roller ball (Microsoft), optically (PC Mouse), or optomechanically (Logitech). The driver converts this motion into an incremental count proportional to the amount of movement sensed. Each unit of this count is equal to approximately .01 inch and is called, for reasons I cannot

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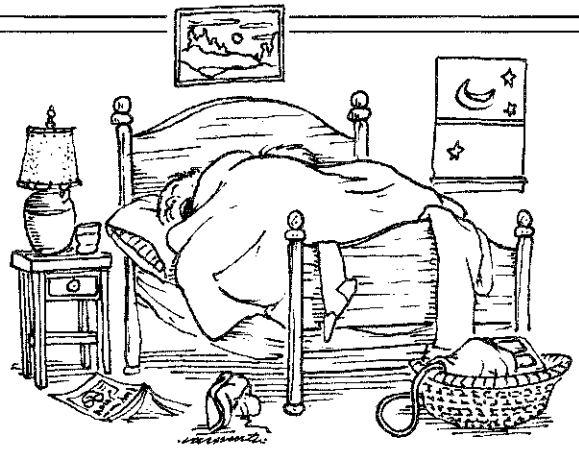

fathom, a *mickey*. If the mouse is moved 1.50 inches to the left, the driver will count 150 horizontal mickeys. If the mouse is moved down .50 inch, the driver will count 50 mickeys.

The internal value of a mickey is always .01 inch and cannot be changed by the programmer, but the programmer can control the mickey-to-pixel ratio. The default values for the mickey-to-pixel ratio are 8 to 8 horizontally and 16 to 8 vertically. Some simple arithmetic here will show that with the default values, the mouse must be moved 0.08 inches horizontally to displace the cursor 1 text column and 0.16 inches vertically to displace the cursor 1 text row. Since the screen is a matrix of 80 columns and 25 rows, 6.4 inches of movement are required to traverse the screen horizontally and 4 inches to traverse it vertically. This means that, using default values, a user requires 25.60 square inches of desk area to access the entire screen. This can easily be changed under program control by setting the desired mickey-to-pixel ratio, which is variable from 0 to 32,767.

A Turbo Pascal Mouse Unit

Let's turn our attention now to the mouse driver. The driver is memory resident and is installed either as a device driver (MOUSE.SYS) or as an executable program (MOUSE.COM). All commercial mouse systems are delivered with a proprietary mouse driver that may operate through a serial port or through an installable bus card. The type of hardware interface and the architecture of the actual resident driver are of no concern to the programmer. The eighteen function calls to the driver are standardized and make it possible to include mouse service routines in a program with the assurance that the program will be properly responsive to any manufacturer's mouse. I'll be discussing each function call in detail in the following paragraphs, and each call will be implemented in a Turbo Pascal 4.0 routine. Access to the mouse driver interrupt will be via Turbo's INTR procedure. Register values will be set and retrieved using a variable declared as Turbo's intrinsic REGISTERS type. Personally, I eschew the Turbo mechanism whenever I can. I've coded a routine for the library of another Pascal compiler and can tell you that a lot of overhead is involved in saving and setting up the registers to make the call. If you want maximum speed and code compactness, use Turbo INLINE code instead. Those of you who view INLINE as tedious and difficult to write probably don't have Dave Baldwin's excellent public domain INLINE assembler (INLINE.ARC is available on CIS and many other BBS's).

Since the mouse routines will be coded in Turbo 4.0, I present them as a Turbo UNIT called MOUSE. At the beginning of Listing 1 you see the unit INTERFACE declarations for MOUSE unit.

Turbo 4.0 users will note that the implementation declarations have the parameter lists commented out in keeping with compiler requirements.

Initializing the Mouse

The first task of the MOUSE unit is to determine if a mouse driver is installed and to initialize it if it is. This is accomplished in the single Turbo function **InitializeMouse**. This function accomplishes four things. First, it determines if a mouse driver is present and responding through interrupt 33H. Second, it initializes a Boolean variable for later use that is set according to the availability of the driver. Third, it initializes all mouse settings to their default values, and fourth, it returns the number of buttons on the installed mouse. DOS Version 2 and some generic versions of DOS 3.x do not initialize the interrupt vector used by the mouse; therefore, you must test that interrupt 33h is not 0 before you invoke the mouse function vector. Otherwise, your program goes off the deep end and starts to execute whatever is located at 0000:00, hanging the machine. The mouse driver defaults are set by this function as follows:

Cursor	Screen center
Cursor status	Hidden
Soft cursor type	Inverse video box
Graphics cursor type	Arrow shape
Graphics cursor area	(-1,-1)
User call mask	Null
Light-pen emulation	Active
Horizontal mickey/pixel ratio	8/8
Vertical mickey/pixel ratio	16/8
Horizontal cursor limits	0 to 639
Vertical cursor limits	0 to 199

Buttons and Cursors

Now is a good time to talk about the number of buttons on the mouse. Microsoft has stubbornly (and wisely, I think) stuck with two while Logitech and Mouse Systems continue to provide three buttons. Extensive man-machine interface research has shown that more buttons are not necessarily better. A good example is the Macintosh mouse, which has only one button. I find that while the third button by itself can be useful, remembering what all the button combinations do can be a chore. In either case, this function will tell the programmer how many buttons are actually being serviced by the driver, and he or she can then decide how many buttons to support.

The next two routines control the visibility of the mouse soft cursor. They must be invoked alternately since a call to

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ShowSoftCursor actually causes a flag to be incremented and a call to **HideSoftCursor** decrements the flag. From the driver's aspect, if the flag is equal to -1, the cursor is to be hidden and if it is equal to 0, the cursor is to be shown. Two successive calls to either one of these routines will destroy the intended toggle effect. For this reason, I've added a cursor visibility variable (**CursorHidden**) that is toggled by each function and can be checked prior to calling either routine.

Mouse driver function 3 is quite useful and will probably be the most frequently invoked routine in this set. **MousePosition** returns a button status value that tells us which, if any, mouse button was pressed. It also returns the current horizontal and vertical position of the cursor. Which button has been pressed is a function of how the bits are set in the BX register upon return from call as follows:

Button(s) Pressed	Value of BX
None	0
Left	1
Right	2
Left & right	3
Middle	4
Left & middle	5
Right & middle	6
Right & middle & left	7

Notice that I've coded the call to function 3 to convert the returned raw horizontal and vertical pixel positions to coordinates scaled to the 80 x 25 text screen.

Mouse driver function 4 is the counterpart of function 3 in that it commands the driver to move the cursor to a specified position. If operating in the 80 column text mode, the horizontal and vertical cursor coordinates should be multiples of 8. Since the 80 column mode is the mode most likely to be in effect, I've coded this routine to convert from 80 x 25 screen coordinates to pixel values.

The next two driver functions (5 and 6) retrieve information on button presses and releases. Providing button release as well as button press information extends the programmer's control of the mouse environment. Both functions require an indication of which button is to be checked. Use the same values listed for function 3 for setting the BX register to indicate the desired button to check. Note that these functions also return the position of the cursor at the time of the last button press and that both Turbo routines scale the returned values for the 80 column text screen.

Mouse Driver functions 7 and 8 set the horizontal and vertical limits of the cursor. Once set, the cursor will be confined to the specified limits. Interestingly, it doesn't really matter which value, maximum or minimum, is placed in which register since the driver will automatically choose the lowest of the two as the minimum. For simplicity and economy of code, I have included setting both the horizontal and vertical limits in one Turbo procedure. Once again, the values are scaled so that the programmer can call the procedure with normal 80 column text values.

Graphics Cursor Shape and Type

We now come to the driver function that controls the shape of the graphics cursor and defines a cursor "hot spot" area. The hot spot is an area within the defined shape that determines which location will be reported at the time of a button press. This area is bounded by pixel coordinates that can vary from –16 to +16 for both axes, with the upper left corner defined as 0,0. You might notice that by using negative coordinate values, you can define a hot spot that is actually outside the cursor area.

The cursor shape is determined by the values contained in two consecutive arrays of 16 integers each. The first array is a screen mask that the driver will AND with a 16 by 16 bit screen area. The second array is a cursor mask that is XORed by the driver with the result of the AND operation to produce the final cursor. The address of the screen and cursor masks is placed in the ES:DX register pair. A simple but effective method to design the desired cursor shape is to use a 16 by 16 bit matrix as illustrated below:

```
    0 1 2 3 4 5 6 7 8 9 A B C D E F  Value
0                                    0000H
1                                    0000H
2                 1                  0080H
3               1 1 1                01C0H
4             1 1 1 1 1              03E0H
5           1 1 1 1 1 1 1            07F0H
6         1 1 1 1 1 1 1 1 1          0FF8H
7       1 1 1 1 1 1 1 1 1 1 1        3FFBH
8         1 1 1 1 1 1 1 1 1          0FF8H
9           1 1 1 1 1 1 1            07F0H
A             1 1 1 1 1              03E0H
B               1 1 1                01C0H
C                 1                  0080H
D                                    0000H
E                                    0000H
F                                    0000H
```

The values in the typed constant array **GraphicsCursorShapeMask** were derived from this matrix. The screen mask has all bits set to 1 so that the screen area under the cursor is visible. Note that **DefineGraphicsCursor** uses a Turbo untyped variable to pass the segment and offset address of the double integer array containing the screen and cursor mask bit values. Setting HotX and HotY each to a value of 8 will place the hot spot in the near center of the diamond cursor.

Mickeys, Lightpens, and User Defined Miscellaneous Calls

Function 11 of the mouse driver supports setting either the hard or soft text cursor. A value of 0 placed in the BX register selects the soft cursor while a value of 1 selects the hard cursor. The parameters **First** and **Last** define the start and end lines of the cursor, thus defining its shape. To completely hide the hard cursor on a CGA, set **First** to 9 and **Last** to 0.

Directly reading the mickey count (mouse motion counters) is accomplished through function 11. The mickey count can vary from 0 to 32,767, and direction is indicated by the sign of the returned values. A positive value is returned for motion to the right or downward, and a negative value indicates left or upward movement.

The mouse driver also provides the means to have a user defined routine called by the driver whenever a specified event occurs. The ES:DX register pair is set to the segment:offset address of a user defined procedure. The mouse driver makes a far call, and therefore the Turbo procedure should be marked accordingly using the **{$F+}** and **{$F-}** compiler directives. Your procedure must accomplish some housekeeping if this interface with the mouse driver is to be effected successfully. I suggest using the intrinsic Turbo 4.0 INTERRUPT directive, which will automatically save all the

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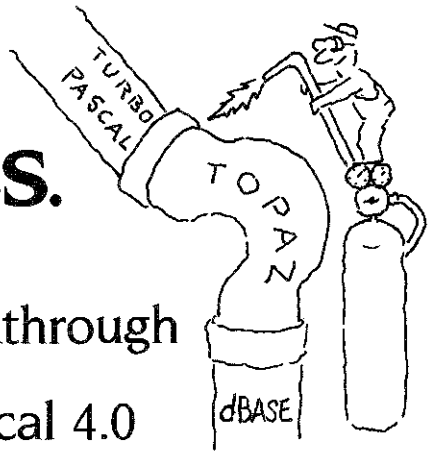

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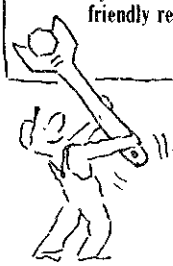

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registers and set up the data and stack segments properly. However, since the Turbo INLINE procedure is designed to handle an interrupt call, it will exit using an IRET. Therefore, it will be necessary to include the following Turbo INLINE code so that your procedure exits with a return far (RETF):

```
Inline(
 $8B/
 $E5/
 $5D/
 $07/
 $1F/
 $5F/
 $5E/
 $5A/
 $59/
 $5B/
 $58/
$CB);
```

Function 12 is called with the ES:DX register pair pointing to your procedure and the CX register set according to which button press or release you desire as a trigger, as follows:

CX = 1	Cursor position change	(bit 0 set)
CX = 2	Left Button pressed	(bit 1 set)
CX = 4	Left Button released	(bit 2 set)
CX = 8	Right Button pressed	(bit 3 set)
CX = 16	Right Button released	(bit 4 set)

The user defined procedure must be of the form

```
Procedure MouseUserProc(AX,BX,CX,DX : integer);
```


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Upon return, the AX register contains the event mask with the corresponding bit set if the specified event occurred, the BX register contains the button status, and the CX and DX registers contain the horizontal and vertical mouse positions.

Light-Pen Support

Light-pen support is provided by driver functions 13 and 14, but since Turbo 4.0 lacks any built in light-pen support and there seems to be little interest in light-pen programming, I'll skip these functions.

Setting the Mickey-to-pixel Ratio

The sensitivity of the mouse can be controlled through function 15, which sets the mickey to pixel ratio. Sensitivity is determined by the number of mickeys (stored in the mouse driver motion counters) the mouse must be physically moved to effect a cursor movement of 8 pixels. The values of the parameters **Horiz** and **Vert** may vary from 0 to 32,767.

The last driver function is number 19 (what happened to 16,17, and 18, I don't know). This function sets the threshold for doubling the motion of the cursor. When physical movement of the mouse exceeds this threshold, the cursor will be moved twice as fast. After the threshold is exceeded, it must be turned off to return the cursor motion to normal. A method of doing this is to set the threshold to 32,767.

Listing 2 is a Turbo 4.0 program that uses the Mouse unit and demonstrates how you might integrate the mouse with the keyboard. This program doesn't actually do very much. It clears the screen, writes a five item menu, places the cursor bar over the first item, and then waits for either keyboard or mouse input. Mouse input can be in the form of a button press or mouse movement. If the mouse is moved up or down, the cursor bar is moved from item to item accordingly. The same movement will occur with the pressing of the up or down arrow keys. The "sensitivity" of the cursor bar can be adjusted by changing the values of the constants **HiLimit** and **LoLimit** in conjunction with the delay statement. Also note that if a mouse driver is not present, menu operation will still be normal and will be responsive to cursor pad keys.

The mouse can be a powerful user interface device, and providing organic support in your programs really won't cost you much in extra code. Remember that Turbo 4.0 will not link the procedures declared in the mouse unit that are not actually called by your program. If you're designing software that you expect a wide variety of people to use, many will be grateful for the opportunity to employ their beloved mice. ◆

John J. Newlin is a retired Naval Aviator who works for Hughes Aircraft Co. as a systems engineer. John holds degrees in mathematics and computer science and has programmed extensively in assembly, Turbo Pascal, Marshal Pascal, and Modula 2. John is the author of SCOUT, a memory-resident disk/file/directory manager, and ARCMASTER, a "point and shoot" style interface between the user and ARC and de-ARC programs. John is a charter member of the Association of Shareware Professionals. Readers may write to John at the following address:

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Code follows.

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Code from "Not a Creature Was Stirring . . ." by John Newlin 1

Listing 1

```
UNIT MOUSE;

  INTERFACE

  Uses Dos;

  Const
    Mouse = $33;
    GraphicsCursorScreenMask : array[1..16] of word =
        ($FFFF,$FFFF,$FFFF,$FFFF,$FFFF,$FFFF,$FFFF,$FFFF,
         $FFFF,$FFFF,$FEFF,$FFFF,$FFFF,$FFFF,$FFFF,$FFFF);
    GraphicsCursorShapeMask : array[1..16] of word =
        ($0000,$0000,$0080,$01C0,$03E0,$07F0,$0FF8,$3FFB,
         $0FF8,$07F0,$03E0,$01C0,$0080,$0000,$0000,$0000);
    Buttons : integer = 0;

  Var
    Regs : Registers;
    MouseAvail,SoftCursorHidden : boolean;
    MouseButtons : integer;
    Function InitializeMouse : integer;
    Procedure ShowSoftCursor;
    Procedure HideSoftCursor;
    Function ReadMousePosition(var MouseX,MouseY : integer) : integer;
    Procedure SetMousePosition(MouseX,MouseY : integer);
    Function MouseButtonPresses(Button : integer; Var MouseX,MouseY : integer) :
      integer;
    Function MouseButtonReleases(Button : integer; Var MouseX,MouseY : integer) :
      integer;
    Procedure MouseCursorLimits(MinX,MaxX,MinY,MaxY : integer);
    Procedure DefineGraphicsCursor(HotX,HotY : integer; Var Mask);
    Procedure DefineTextCursor(HardOrSoft,First,Last : integer);
    Procedure MouseMickeyCount(Var MouseX,MouseY : integer);
    Procedure SetMouseUserProc(EventMask : integer; Var ProcAddr);
    Procedure MickeyToPixelRatio(Horiz,Vert : integer);
    Procedure HighSpeedThreshold(Threshold : integer);

IMPLEMENTATION

    Function InitializeMouse : integer;
    begin
      if  MEMW[$0000:$00CC]= 0 then
        begin
          InitializeMouse := 0;
          Exit;
        end;
      Regs.AX := 0;
      Intr(Mouse,Regs);
      MouseAvail := Regs.AX = 65535;
      if MouseAvail then InitializeMouse := Regs.BX else
        InitializeMouse := 0;
    end;

    Procedure ShowSoftCursor;
    begin
      Regs.AX := 1;
      Intr(Mouse,Regs);
      SoftCursorHidden := false;
    end;

    Procedure HideSoftCursor;
    begin
      Regs.AX := 2;
      Intr(Mouse,Regs);
      SoftCursorHidden := true;
    end;

    Function ReadMousePosition { (var MouseX,MouseY : integer) } : integer;
    begin
      Regs.AX := 3;
      Intr(Mouse,Regs);
      MouseX := succ(Regs.CX div 8);
      MouseY := succ(Regs.DX div 8);
      Intr(Mouse,Regs);
      ReadMousePosition := Regs.BX
    end;

    Procedure SetMousePosition { (MouseX,MouseY : integer) } ;
    begin
      Regs.AX := 4;
      Regs.CX := pred(MouseX * 8);
      Regs.DX := pred(MouseY * 8);
      Intr(Mouse,Regs);
    end;

    Function MouseButtonPresses { (Button : integer; Var MouseX,MouseY : integer) } :
                                integer;
    begin
      Regs.AX := 5;
      Regs.BX := Button;
```

Code continues . . .

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Newlin Code, Continued


```
    Intr(Mouse,Regs);
    MouseX := succ(Regs.CX div 8);
    MouseY := succ(Regs.DX div 8);
    MouseButtonPresses := Regs.AX;
  end;

  Function MouseButtonReleases { (Button : integer; Var MouseX,MouseY : integer) } :
                                 integer;
  begin
    Regs.AX := 6;
    Regs.BX := Button;
    Intr(Mouse,Regs);
    MouseX := succ(Regs.CX div 8);
    MouseY := succ(Regs.DX div 8);
    MouseButtonReleases := Regs.AX;
  end;

  Procedure MouseCursorLimits { (MinX,MaxX,MinY,MaxY : integer) } ;
  begin
    Regs.AX := 7;
    Regs.CX := pred(MinX * 8);
    Regs.DX := pred(MaxX * 8);
    Intr(Mouse,Regs);
    Regs.AX := 8;
    Regs.CX := pred(MinY * 8);
    Regs.DX := pred(MaxY * 8);
    Intr(Mouse,Regs);
  end;

  Procedure DefineGraphicsCursor { (HotX,HotY : integer; Var Mask) } ;
  begin
    Regs.AX := 9;
    Regs.BX := HotX;
    Regs.CX := HotY;
    Regs.DX := ofs(mask);
    Regs.ES := seg(mask);
    Intr(Mouse,Regs);
  end;

  Procedure DefineTextCursor { (HardOrSoft,First,Last : integer) } ;
  begin
    Regs.AX := 10;
    Regs.BX := HardOrSoft;
    Regs.CX := First;
    Regs.DX := Last;
    Intr(Mouse,Regs);
  end;

  Procedure MouseMickeyCount { (Var MouseX,MouseY : integer) };
  begin
    Regs.AX := 11;
    Intr(Mouse,Regs);
    MouseX := Regs.CX;
    MouseY := Regs.DX;
  end;

  Procedure SetMouseUserProc { (EventMask : integer; Var ProcAddr) };
  begin
    Regs.AX := 12;
    Regs.CX := EventMask;
    Regs.DX := ofs(ProcAddr);
    Regs.ES := seg(ProcADDr);
    Intr(Mouse,Regs);
  end;

  Procedure MickeyToPixelRatio { (Horiz,Vert : integer) } ;
  begin
    Regs.AX := 15;
    Regs.CX := Horiz;
    Regs.DX := Vert;
    Intr(Mouse,Regs);
  end;

  Procedure HighSpeedThreshold { (Threshold : integer) } ;
  begin
    Regs.AX := 19;
    Regs.DX := Threshold;
    Intr(Mouse,Regs);
  end;

begin
  Buttons := InitializeMouse;
end.
```

Listing 2

```
Program MouseMenuDemo;

Uses Crt,Dos,Mouse;
Type
  Str30 = string[30];

Var
  Result : byte;
  i : integer;

Const
  MaxItems = 5;
  UpArrow = #200;          {Up arrow OR $80}
  DownArrow = #208;        {Down arrow OR $80}
  Home  = #199;            {Home OR $80}
  EndKey = #207;           {End OR $80}
  Inverse = $70;
  Normal = $0E;
```

Code continues . . .

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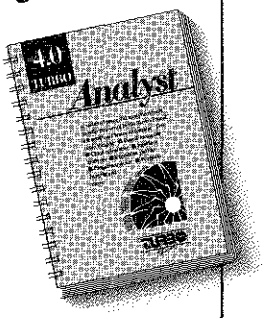

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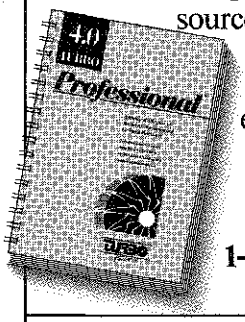

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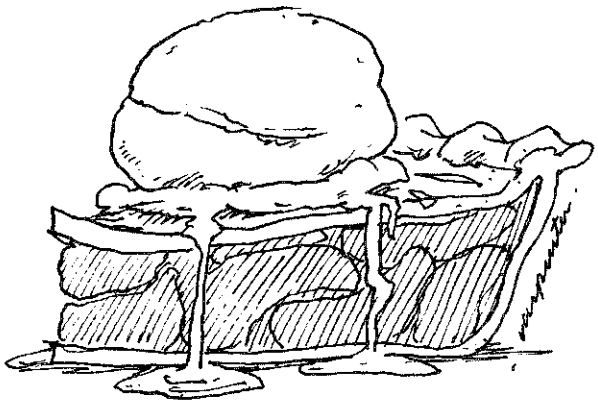

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```
   LB  = 1;
   RB  = 2;
   LRB = 3;
   MB  = 4;
   LMB = 5;
   MRB = 6;
   LMR = 7;
   MenuItem : array[1..MaxItems] of str30 =
      (' Menu Item #1 ',
       ' Menu Item #2 ',
       ' Menu Item #3 ',
       ' Menu Item #4 ',
       ' Menu Item #5 ');

Function GetAKey : byte;
Var X1,Y1,x,y,Button,SaveAttr,Item : integer;
    KeyPress : boolean;
    Ch : char;
Const
    HiLimit = 16;
    LoLimit = 8;
Label Top;
begin
  x := 30;
  y := 9;
  Top:
  if MouseAvail then
    begin
      SetMousePosition(40,12);
      MickeyToPixelRatio(40,8);
    end;
    Button := 0;
    Repeat
      gotoxy(x,y);
      TextAttr := inverse;
      write(MenuItem[y-8]);
      KeyPress := Keypressed;
    If (not keypress) and MouseAvail then Button := ReadMousePosition(X1,Y1);
    Until Keypress or (Button  > 0) or (Y1  < LoLimit) or (Y1  > HiLimit);
    If Button > 0 then
     case Button of
       LB : Ch := chr(y-8);
       MB : Ch := Home;
       RB : Ch := #255;
     end
    else if (not KeyPress) and MouseAvail then
      begin
        if y1  > HiLimit then ch := DownArrow;
        if y1  < LoLimit then ch := UpArrow;
        delay(200);
      end
    else
      begin
       if button = 0 then Ch := ReadKey;
       if button = 0 then if Ch = #0 then Ch := Chr(Ord(ReadKey) or $80);
      end;
    TextAttr := Normal;
    gotoxy(x,y);
    write(MenuItem[y-8]);
    case ch of
      DownArrow : if y  < 13 then y := succ(y) else y := 9;
      UpArrow   : if Y  > 9 then y := pred(y) else y := 13;
      #13       : ch := chr(y-8);
      Home      : begin
                    y := 9;
                    goto top;
                  end;
      EndKey    : begin
                    y := 13;
                    goto top;
                  end;
    end;
    if ch in [UpArrow,DownArrow] then goto top;
    GetAKey := ord(ch);
  end;

Procedure Action(Item : byte);
begin
  clrscr;
  gotoxy(10,10);
  write('Menu item ',item,' was selected');
  repeat until keypressed;
end;

begin
  TextAttr := Normal;
  clrscr;
  DefineTextCursor(1,9,0);  {Hide the cursor on a CGA}
  for i := 1 to 5 do
    begin
      gotoxy(30,i+8);
      write(MenuItem[i]);
    end;
  repeat
    Result := GetAKey;
    gotoxy(1,25);
    if result in [1..5] then Action(result);
  until (Result in [1..5]) or (result = 27);
  DefineTextCursor(1,7,8);
end.
```


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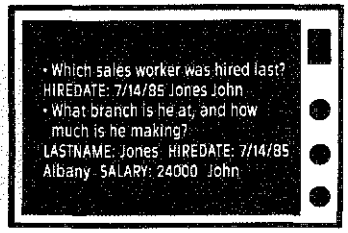
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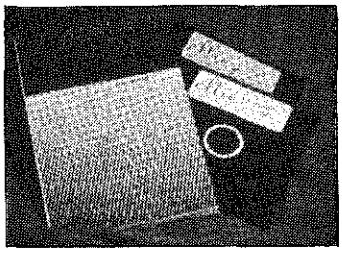

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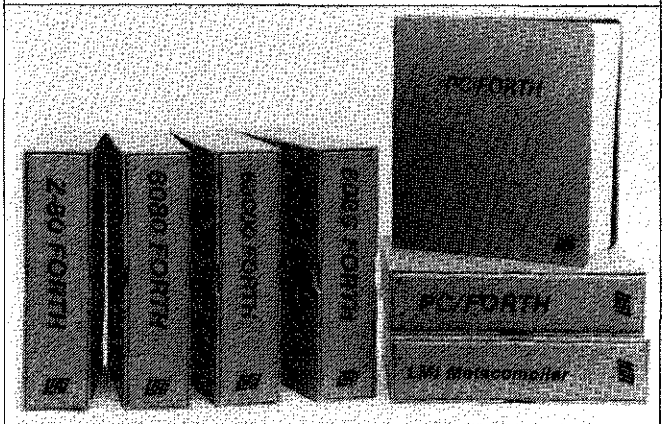

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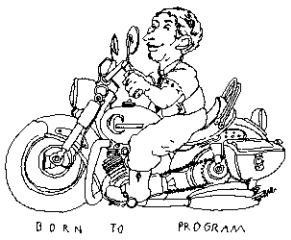

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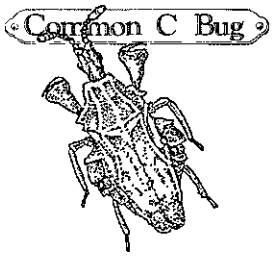

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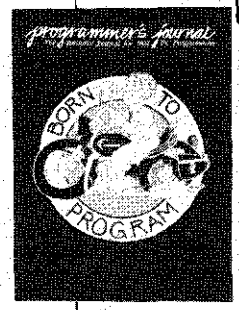

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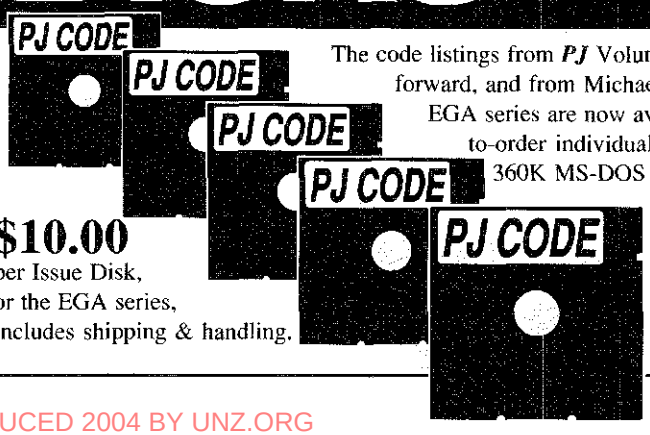

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Windowing and Graphics

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The *Microsoft Mouse Programmer's Reference Guide* ($25) comes with utility programs to design mouse menus, two object library files to build mouse support into applications, and programming examples (one 5.25-inch disk). The first four chapters describe how to use the Mouse Menu software to design menus. The last four chapters detail the mouse software interface, mouse functions, making function calls from various languages, and writing mouse programs for IBM EGA modes. The VGA chip is not mentioned. Examples are provided to show how to interface with the BASIC interpreter, QuickBASIC 2.0, Microsoft Pascal, FORTRAN, C, and MASM. A special EGA Register Interface library is provided for writing applications for EGA graphic modes D, E, F, and 10H. This library saves the state of various write-only EGA registers so that the mouse cursor will be updated correctly. Brief appendices cover mouse driver command-line switches, differences between Versions 5.0 and 6.0 mouse drivers, making calls to Borland Turbo Pascal, and using a Hercules card.

GEM/3 Programmer's Toolkit
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Digital Research (DRI) has released the latest versions of GEM (Graphics Environment Manager)—the GEM/3 Desktop ($49.95) along with a revised GEM/3 Programmer's Toolkit ($500). The GEM programming environment provides two sets of functions—AES (Application Environment Service) and VDI (Virtual Device Interface)—for controlling graphics device output and pointing device and keyboard input. The GEM Programmer's Toolkit includes C-language bindings to facilitate calling the functions and to help develop portable programs. The kit also provides a GEM resource construction program, a series of C-language include files, and a symbolic debugger. GEM/3 supports more graphics devices than GEM 2.2 and adds more font support and greater speed of operation (redraw speed on CGA and VGA cards is up to four times faster). GEM/3 AES allows the choice of either drop-down or pull-down menus and control of menu bar activation. The GEM/3 VDI allows a simpler program invocation scheme (similar to that currently used by Xerox's Ventura Publisher 1.1 under GEM). GEM/3 also provides greater support for runtime selection of output destination, page size and orientation, number of copies, justified text, and rotated and scaled bit images, and more fonts are supported. The DOS version comes bundled with Bitstream's Fontware package, which allows generating screen and printer fonts in any size from 6 to 72 points (HP Laserjet II). The package comes with both Helvetica and Times Roman style fonts in normal, bold, italic, and bold italic along with Bitstream Charter—a newer Roman style font.

Toolkit documentation (500+ pages) includes three volumes: (1) *GEM AES* (higher level window and object functions); (2) *GEM VDI* (lower level graphics primitives); and (3) *RCS*—Resource Construction Set (utilities for constructing graphic resources and the debugger). An addendum documents changes and additions from GEM 2.2 to GEM/3. The list of GEM/3 compatible devices is extensive, with graphics displays (120+) ranging from low resolution monochrome and color to ultra high resolution, pointing devices (12 different mice and PC keyboard), tablets, scanners, camera devices, and about 80 output devices—plotters, phototypesetters, monochrome, color, and laser printers.

Prospero GEM Pascal & FORTRAN
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Prospero Software from England is one example of the recent trend to export to the U.S. market better European software. For some time, now, Prospero has sold DOS Pascal and FORTRAN compilers into the U.S., and last fall the company opened a U.S. office to provide better marketing and technical support for their products. Closely following their increased U.S. presence, Prospero has released new Pascal and FORTRAN compilers designed specifically for GEM, for both DOS (80x86) and the Atari ST (68000). In the European market, DRI's GEM and Concurrent-DOS have consistently held a larger market share than in the U.S. And in Britain, the Atari ST is a more popular personal computer than it is here.

The Prospero GEM Compilers (Pascal at $149 and FORTRAN at $199) include a programming environment with a workbench to control the editor, compiler, linker, librarian, cross-reference utility, and symbolic debugger using pull-down menus and a multi-window display. The workbench editor supports the standard WordStar control key sequences along with cursor and special function keys and user-defined macros. All four compilers have full GEM VDI and AES bindings. In order to use the MS-DOS compilers, you also need to buy a version of the GEM Desktop. Each compiler comes with a three volume set of documentation (800+ pages) describing (1) the specific compiler, (2) the language VDI bindings, and (3) the language AES bindings. Both the DOS Pascal and the FORTRAN compilers have been validated for compliance by the National Bureau of Standards. The versions for MS-DOS (8086) are similar to Prospero's regular MS-DOS compilers except that they lack support for the 8087 coprocessor and only the large memory model is supported. Also, the GEM DOS linker does not support overlays. The GEM VDI and AES Pascal and FORTRAN bindings are especially convenient since DRI's GEM toolkit is based on C and assembly language bindings. If you are developing software targeted at both the Atari ST and the IBM PC (for example, music software), these compilers might provide you a portable window to both worlds.

Standards

System V Interface Definition
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Several years ago, in order to help standardize the programmer's interface to Unix and promote portability, AT&T drafted and published the System V Interface Definition (SVID). The SVID Release 2 consists of three attractive perfect bound manuals documenting Unix System V. These publications are intended to serve as a single reference source for the definition of the external interfaces to services provided by all System V environments, to define all additional services (such as networking and data management) provided as extensions, and to serve as a complete definition of System V interfaces for application source code.

Volume I (320 pages) covers the base system definition—the basic Unix Library and Operating System (OS) calls. Volume I also covers Kernel Extensions to support process accounting, software development (profiling and debugging), and enhanced interprocess communication (messages, semaphores, and shared memory). Volume II (460 pages) covers the Base Unix utilities, Advanced utilities, and Administered utilities—the commands available under System V Unix. Volume II also details software development utilities (the C Preprocessor and Compiler, the linker and debugger, lex, yacc, make, etc.) and the terminal interface definition (Curses and Terminfo databases). Volume III (380 pages) contains addenda to the Base System Definition and documents new capabilities introduced to System V with Release 3.0.

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Volume III also covers changes to Terminfo, Curses, and network extensions—the Streams I/O, Shared Resource Environment, and Open Systems Network (OSI Model) interfaces.

I found the three volume set an excellent reference to Unix commands, libraries, and the Terminfo/Curses terminal interface, and also to how the equivalent C library routines and kernel services might be expected to function under DOS C compilers. If you are porting programs from Unix to DOS, these volumes could help you write Unix compatible DOS library functions not supported by your DOS C development environment. Single volumes ordered separately cost $37, while the entire set is priced at $84.

C Math Libraries

C Scientific Library
Eigenware Technologies
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The C Scientific Library (CSL) from Eigenware Technologies is a scientific programming library of over 400 math functions. CSL is supplied as seven libraries available for Microsoft C 3.0 through 5.x and Borland's Turbo C. CSL costs $275 for the entire 400+ function library and is also available as three separate libraries (math, statistics, and matrix) for $99 each. CSL functions are provided as linkable object libraries compiled for the small, medium, and large memory models using the 8087 if present or the 8087 emulator (/FPc compiler option). Source code in C for CSL is available for an additional $75. The CSL functions were originally developed and tested using the VAX11 C and Computer Innovations' v2.3 C compiler and were later converted for Microsoft C. The C source code should work with other C compilers, and batch files for compiling and creating linkable libraries are included. A series of example programs is provided.

The CSL function library is comprehensive, covering matrix computation and decompositions, eigensystems and singular value analysis, matrix inversions, matrix multiplexing, linear algebra, differential equations of any order, quadrature, complex variables, polynomials, interpolation, table lookup, simple statistics, probability, analysis of variance, regression, time series, data analysis, discrete and fast Fourier transforms, nonlinear equations, optimization, finance, calendar, sorting, data plotting, and graphics support.

Documentation (over 600 pages) consists of three volumes: (1) *General Information and Tutorial*; (2) *Reference Manual* (the big one); and (3) *Graphics and Plotting*. The documentation is wide ranging, but needs work. The reference manual has no page numbers, the table of contents shows section heads only, and none of the manuals has an index. The reference manual is organized into eleven sections and contains a separate entry for each CSL function describing its purpose, a function header with argument list, a functional description (the algorithm used), function usage (input arguments and output), a code fragment example, references (the source of the algorithm), and related CSL functions. References are noted by book source only, not by pages. The Tutorial makes some interesting comments about a few algorithms, but in general algorithms are not discussed. Appendices to Volume I contain math constants and C function prototypes (also in supplied C header files) and a cross reference of CSL functions that notes other CSL functions and the C library routines required. CSL appears to be a complete package whose documentation needs some improvement to make it easier to use.

C Math Toolbox—Volume I
Silver State Software
1000 E. Williams St., Suite 100
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The C Math Toolbox (Volume I for $89) from Silver State provides 89 math functions designed specifically for use with Microsoft QuickC and C 5.x DOS compilers. The functions in the Toolbox are delivered in three separate forms: (1) C source code; (2) optimized linkable Microsoft C library; and (3) CodeView linkable library. The source code files are in the proper form to be used with either Microsoft 5.x or QuickC. The linkable

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libraries are compiled using the Medium Memory Model to conform to the default QuickC model using inline 8087 code. A set of MAK files (QuickC makefiles) for using the library with QuickC is also provided. The C source code functions should work with other C compilers, and two batch files are provided to recompile and build the libraries. The batch files may be modified for use with other compilers and to generate other memory models. For each math function, an example test program in C is also provided.

The math functions provided cover the following areas: byte matrix manipulation, complex math, real and complex matrix math, solutions to equations, fast Fourier transform, polynomial interpolation, function roots, simple integration, polynomial manipulations, simple statistics, regression, and time series analysis. Documentation consists of a single perfect bound manual of about 270 pages with a table of contents and an index. In general, the source code is not commented and the user is referred to the manual. The manual contains a separate section on each math function: its purpose, other functions used, a C prototype, the function arguments, notes for QuickC use, a reference for the algorithm, and an illustrative example program. The documentation is readable and well organized. The actual algorithms are not explained. References are noted only by book source, not by pages. The references seem a bit dated; none is post 1978, and most are from a decade earlier (this is only Volume I, though, with more to follow). Although the code seems to be translated rather directly from FORTRAN, most optimizing compilers don't really care and will generate the same code for i=i+1 as for i++. But some C coding improvements for speed could probably be made. This appears to be a solid, easy to use package if the areas covered fit your needs.

Compilers and Languages

NDP C-386 Compiler

MicroWay
P.O. Box 79
Kingston, MA 02364
(617) 746-7341

MicroWay has released Version 1.4 of their 80386 C Compiler ($595). Their NDP FORTRAN-386 compiler was released about 6 months ago (see *PJ* 6.1). Now C-386 is off the press, and Pascal-386 is to follow soon. Working with Green Hills Software (Glendale, CA), MicroWay has been porting their family of Unix compilers to DOS for the 80386 using the Phar Lap DOS Extender. MicroWay NDP C-386 generates optimized native 80386 code, supports 80287, 80387 and Weitek math coprocessors with inline code, and includes a DOS compatible C runtime library. The runtime library also includes graphics routines written in 386 assembly language, trace and debugging aids, and support for installing your own interrupt handlers.

Green Hills makes advanced optimizing compilers for FORTRAN 77, C, and Pascal that run on Unix System V, Berkeley Unix, and now 386/DOS. These compilers optimize globally, providing some of the fastest code execution in the business. NDP C-386 is a full implementation of PCC (Bell Labs' Portable C Compiler). The compiler generators optimize 80386 assembly language as output that is then assembled and linked using either Phar Lap 386 development tools on DOS or VAX machines or Unix V utilities. Programs may be run on DOS using Phar Lap's 386 DOS Extender. C-386 generates programs with no limit on size up to the 16 or 24 megabyte limit of most 80386 DOS machines (DOS Extender) or the 4 gigabyte limit under Unix V. A large number of command-line switches are available to control optimizations, extensions, and coprocessor support. Documentation consists of a thorough (340+ pages) manual covering the compiler and its use, C language elements and extensions (some ANSI C draft standard and Microsoft features are supported), interfacing to other MicroWay languages, numeric coprocessor support, trace/debug features, and the runtime library routines. In addition to the compiler, you must buy the Phar Lap Development tools (MicroWay also sells these).

WATCOM C6.0

Watcom
1430 Massachusetts Ave, Suite 306
Cambridge, MA 02138
(800) 265-4555

Watcom has released their WATCOM C6.0 compiler for 80x86 DOS machines. Watcom, a Canadian software house, is not exactly new to the compiler market. They have developed language compilers for machines ranging from the IBM 370 to 8-bit microprocessors. Traditionally, Watcom C compilers have been available only on IBM 370 mainframes. WATCOM C6.0 is a high performance optimizing C compiler and development system (introductory U.S. price $295). The development system includes their ANSI compatible optimizing compiler, an editor, a full screen source-level debugger, runtime libraries, an overlay linker, an object librarian, a make utility, an object module disassembler, and EXPRESS C (Watcom's integrated fast C development system). The compiler supports five memory models (small, medium, compact, large, and huge) under DOS and can generate 8086, 80186, or 80286 code. The 80x87 math chip is supported with both inline code generation and an emulator library.

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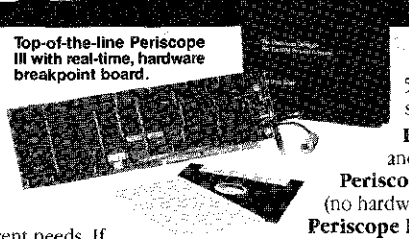

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the 8086. The compiler does the conventional compiler optimizations, but the ultimate performance is a result of parameter passing conventions. Depending on their sizes, arguments are passed either in registers or on the stack. Registers AX, DX, BX, and CX are used first (in that order) to pass arguments to functions before the stack is used. The registers may be grouped together and are used to pass char, int, long, float, double, and both near and far pointers. The 80x87 registers are also used to pass floating point parameters to functions. Since many C functions may have only a few parameters, all the arguments may be passed in registers without being pushed onto the stack. These features may be controlled with #pragma directives on an individual function basis. A side effect of this optimization is that runtime and utility libraries have to be rewritten (if assembly language) or recompiled with WATCOM C to benefit from this enhancement.

The compiler supports a variety of command-line switches to control optimization level, memory models, cpu and math support, warning level, stack checks, debugging, language extensions, and other features. A convenient option allows outputting function prototypes to a file. Language extensions include support for cdecl, pascal, fortran, near, and far function modifiers. Supported pragmas allow powerful extensions and controls including inline assembly language, parameter passing in registers, forcing arguments into specific registers, exporting symbol names, using 80x87 registers (for paramater passing, return function values, and preserving registers across calls), returning structure pointers in registers, and calling near or far functions with FORTRAN or Pascal conventions. EXPRESS C supports the medium memory model and allows for quick development. The exhaustive documentation is spread across five manuals—(1)*Optimizing Compiler and Tool User's Guide*, (2)*Editor User's Guide*, (3)*Library Reference*, (4)*Language Reference*, and (5)*Express C User's Guide*. In short, WATCOM C6.0 is a powerful package for program development.

Guidelines C++ Version 1.2
Guidelines
P.O. Box 749
Orinda, CA 94563
(415) 254-9393 or 254-9183

Need some class for your next programming project? Object oriented programming has been gaining popularity, and C++ provides extensions to the C language to support objects and other levels of abstraction. Guidelines has ported Version 1.2 of AT&T's C++ translator to the DOS environment. Guidelines C++ ($295) is a full implementation and requires Microsoft C 3.0, 4.0, or 5.x and 640K of RAM. Guidelines provides a C++ preprocessor (CPRE.exe) and C++ translator (CFRONT.exe) to generate standard C code compatible with Microsoft C. This translated C code is then compiled and linked with the regular Microsoft C runtime libraries and Guidelines' C++ runtime library. Five memory models are supported—small, compact, medium, large, and huge. Batch files are provided to automate the process. The CPRE preprocessor supports command-line switches to define or undefine names and add search paths for include files. CPRE implements most of the ANSI draft standard. The CFRONT program supports several command-line options to control warning and diagnostic messages, add debug information, use a list of object sizes and alignments from an external file, accept regular (non-ANSI) C function declarations, and generate line number information. The C++ translator was developed in the Unix environment, where memory size is not a consideration, but it's possible to run out of memory in the DOS version (CFRONT is a 285K executable file). If you look at the actual C output files from the translator, you'll see that they are a bit difficult to interpret, with #line directives and no C pretty formatting. But these line directives let the C compiler report the errors back to the C++ input file.

Documentation consists of *The C++ Programming Language* by Bjarne Stroustrup, the current equivalent of Kernighan and Ritchie for C++, and a Guidelines C++ trans-

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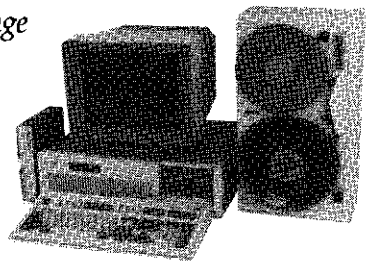

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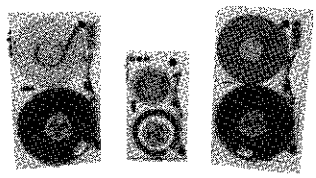

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lator manual. The Stroustrup book (327 pages) provides both a tutorial and a description of C++ by the language's designer. The Guidelines manual (105 pages) includes a few pages on installation and a tutorial, but otherwise consists wholly of the AT&T release notes for C++. The AT&T release notes are divided into three sections: (1) software features and notes, technical tips, and a language overview; (2) complex arithmetic in C++; and (3) a set of C++ Classes for Co-Routines (which are not implemented in Guidelines C++). Two AT&T addenda document changes between Versions 1.1 and 1.2. The manual has a table of contents, but no index. Example programs that correspond with chapters in the Stroustrup book are provided on disk. Although the Guidelines C++ package was ported specifically for Microsoft C under DOS, I was able to compile the translated files with both the MetaWare and the NDP 386 C compilers. Of course, to generate executable files, you would have to write equivalent C++ library functions to replace those provided in the Guidelines supplied libraries (typically 40K).

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I can't do this powerhouse of new products justice in this short synopsis, so my comments will be brief. Microsoft has released six new language products for DOS and OS/2: updated development systems for C ($450), Pascal ($300), FORTRAN ($450), and BASIC (6.0); an updated version of MASM ($150); and an OS/2 Programmer's Toolkit ($350). I've had a chance to briefly review all but the Pascal compiler. The compilers and MASM are bundled with the new Microsoft editor, the linker, the librarian, the CodeView source code debugger, and other utilities. The Microsoft editor (called M in the real mode and MEP in the protected mode) is emacs-like and supports a somewhat configurable keyboard interface. All of these compilers and MASM are provided with versions that execute under both DOS and OS/2 and that support writing bound (dual mode) applications that run under both DOS and OS/2. Only C and MASM offer full support for OS/2, allowing multi-threaded OS/2 applications and dynamic linking. FORTRAN and BASIC support only major features of OS/2, including direct calls to the OS/2 application programmer's interface (API). To support multiple threads and dynamic linking, the runtime libraries of FORTRAN and BASIC must be rewritten.

Each language system comes on a number of 5.25-inch disks (360K for DOS and 1.2 megabyte for OS/2) with a SETUP program. Distribution is available on 3.5-inch disks if you return a coupon to Microsoft. The SETUP program is almost mandatory given the number of disks in each distribution and the complexity of two operating systems, multiple runtime libraries, different memory models, math chip support, and mixed language programming. The SETUP program allows you to choose to install a DOS version, an OS/2 version, or both versions of the language. In each distribution, some programs execute only under OS/2 (the protected mode CodeView and editor), some under DOS or in the OS/2 DOS compatibility box, and some under both DOS and OS/2 as bound (dual mode) applications. It took me about two hours and several tries to get the C compiler and utilities installed for both DOS and OS/2 the way I preferred it. The other packages are less complex and would require less time. The SETUP utility will by default use three different BIN subdirectories for each type of program. Some of these packages have slightly different versions of the same software—the C system's versions of several utilities were newer than MASM's, for instance.

For the most part, the actual compilers have only limited changes from the previous versions with the exception of generating OS/2 code and having OS/2 runtime libraries. For example, the C compiler has the same manual as C 5.0, but with some updates covering compiler changes (60 pages), the editor (120 pages), new or updated utilities, and OS/2 features (73 pages). Changes include two new command-line switches, some new ANSI C features, the addition of several new pragmas, a few new keywords to support DLL and configuring registers, a half dozen new runtime library routines, and a list of functions supported only in the Real Mode. As in the past, the documentation is very good if a bit on the voluminous side.

The language system documentation does not cover the OS/2 API and features, which are covered by the OS/2 Programmer Toolkit documentation. The OS/2 Toolkit contains several tools, documentation, and sample programs for developers writing OS/2 programs. The toolkit disks (distributed on both 5.25-inch and 3.5-inch disks) include example OS/2 programs, Peter Norton's Guide to OS/2 (an online help system called QuickHelp), and several OS/2 utilities, many of which are duplicated in the language system distributions. Documentation is in two manuals: (1) a *Learning Guide* (75 pages) and *Programming Tools* (70 pages); and (2) the *OS/2 Programmer's Reference* (580 pages). The OS/2 Toolkit documents the OS/2 API functions and I/O controls with short appendices on utility macros, screen devices, code pages, OS/2 executable file formats, and ANSI Escape sequences. If you were expecting the OS/2 Toolkit to function as an inexpensive version of the OS/2 Software Developer's Kit (SDK), you'll be disappointed. The Toolkit omits a number of OS/2 features (device drivers and the Presentation Mana-ger, for example) and therefore does not replace the much more expensive OS/2 SDK. ♦

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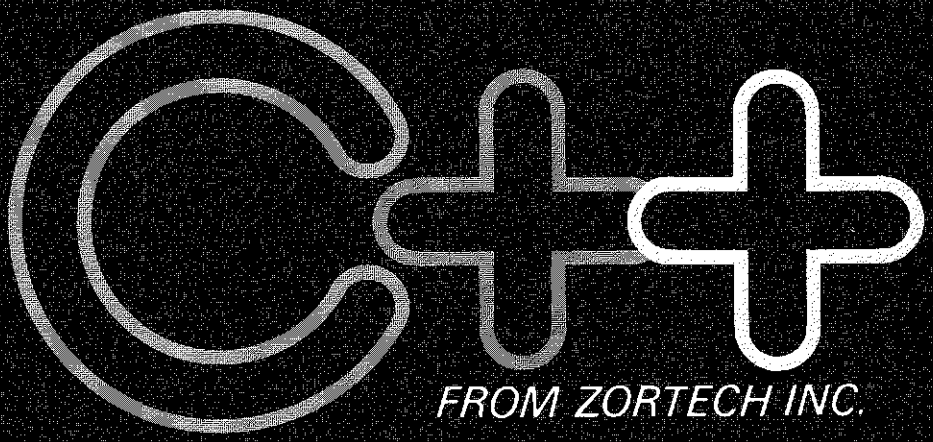

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